

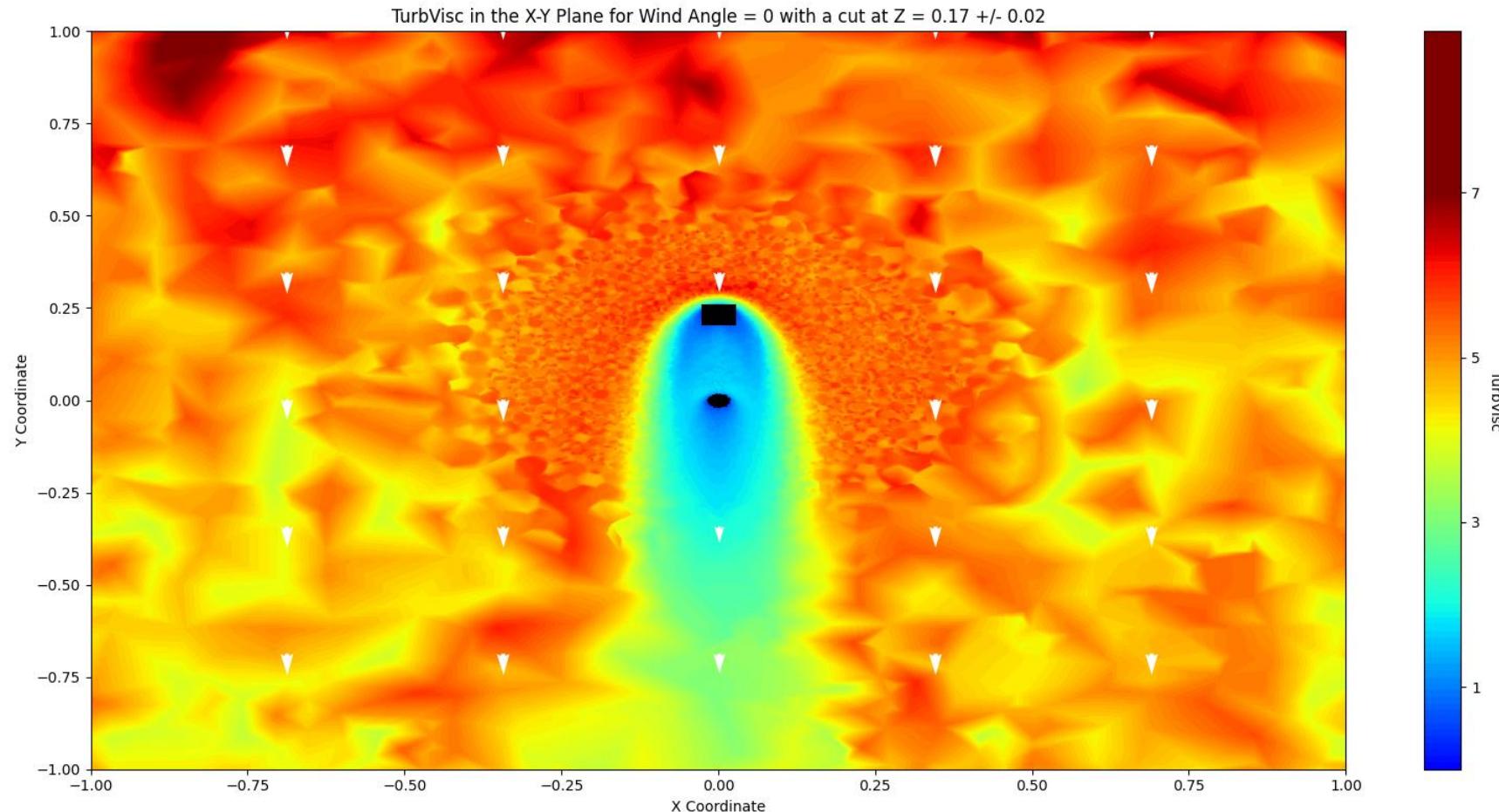
PM005 – 15 November 2023

Update on PINNs

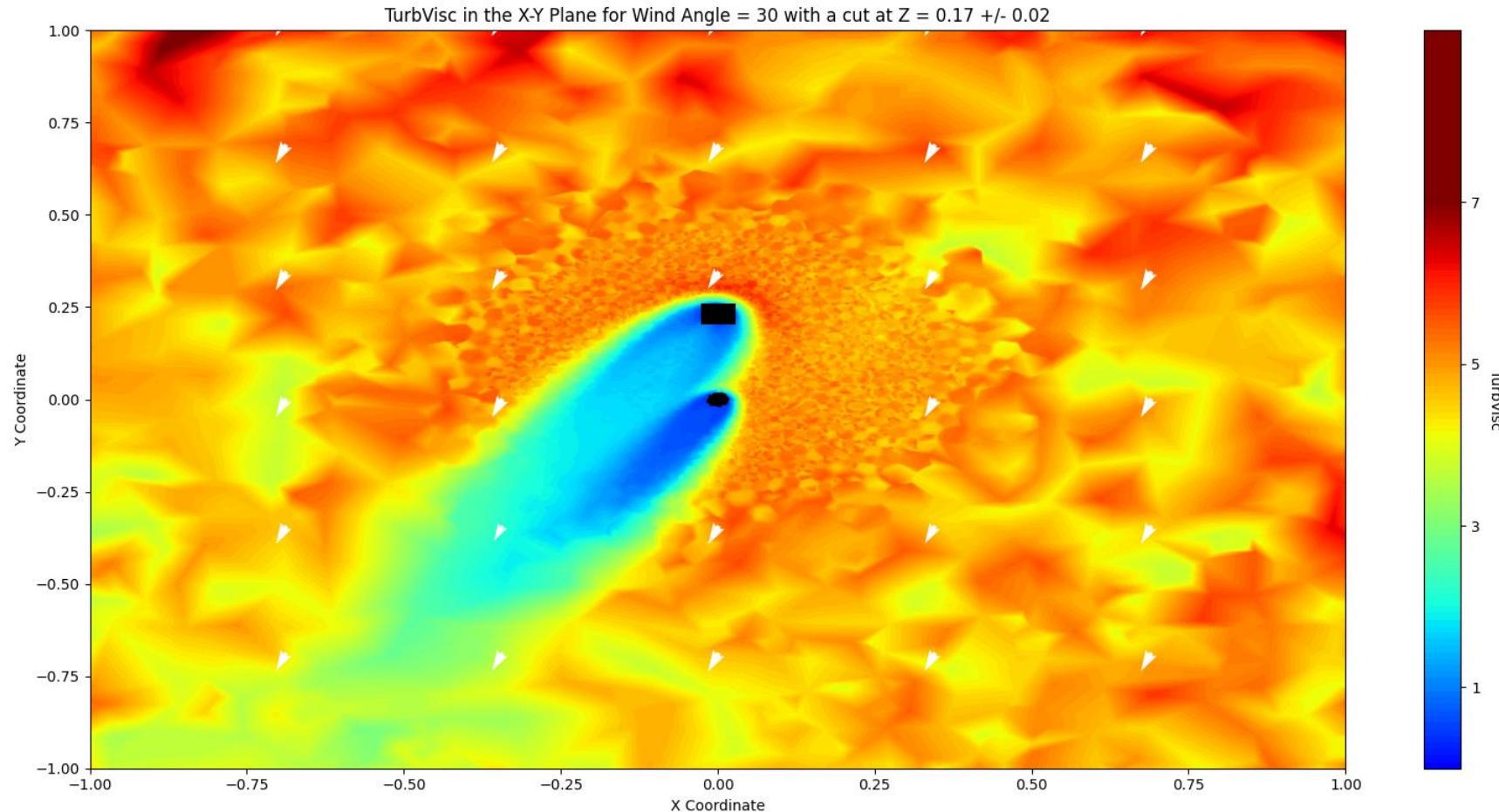
Application to Urban Wind Field Dispersion Studies

Pure Data Plots (TurbVisc)

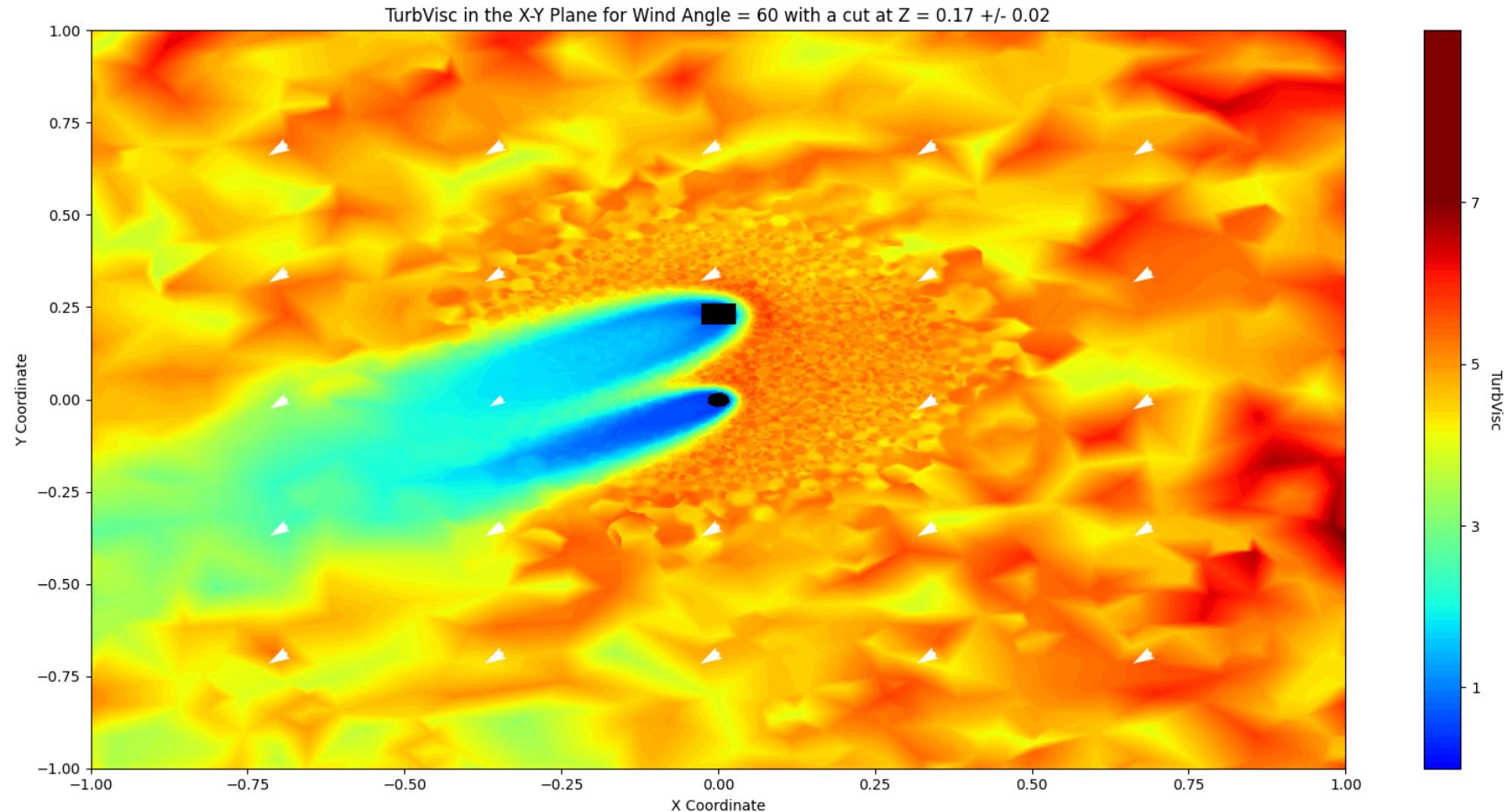
Data Plots – wind angle = 0



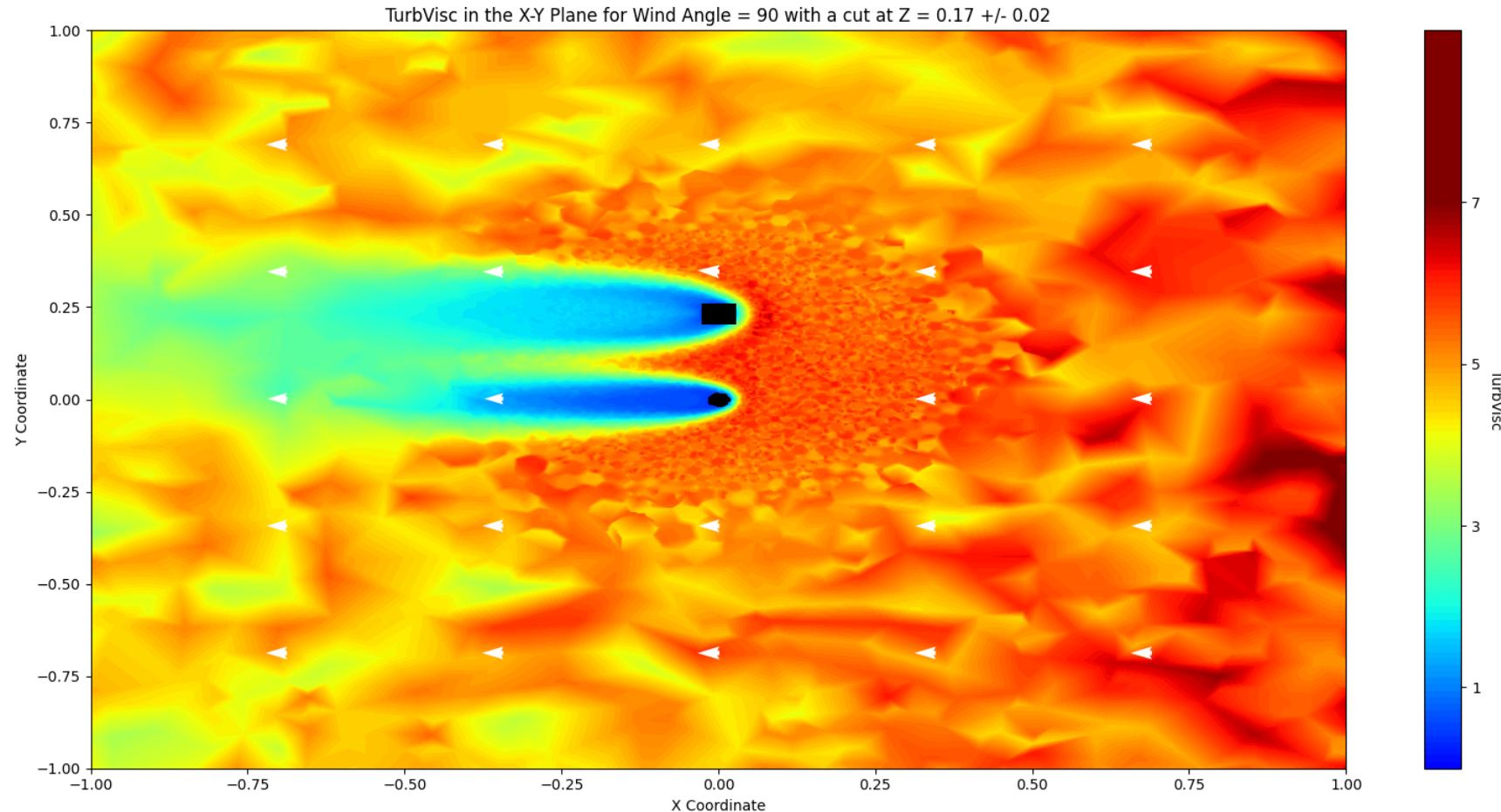
Data Plots – wind angle = 30



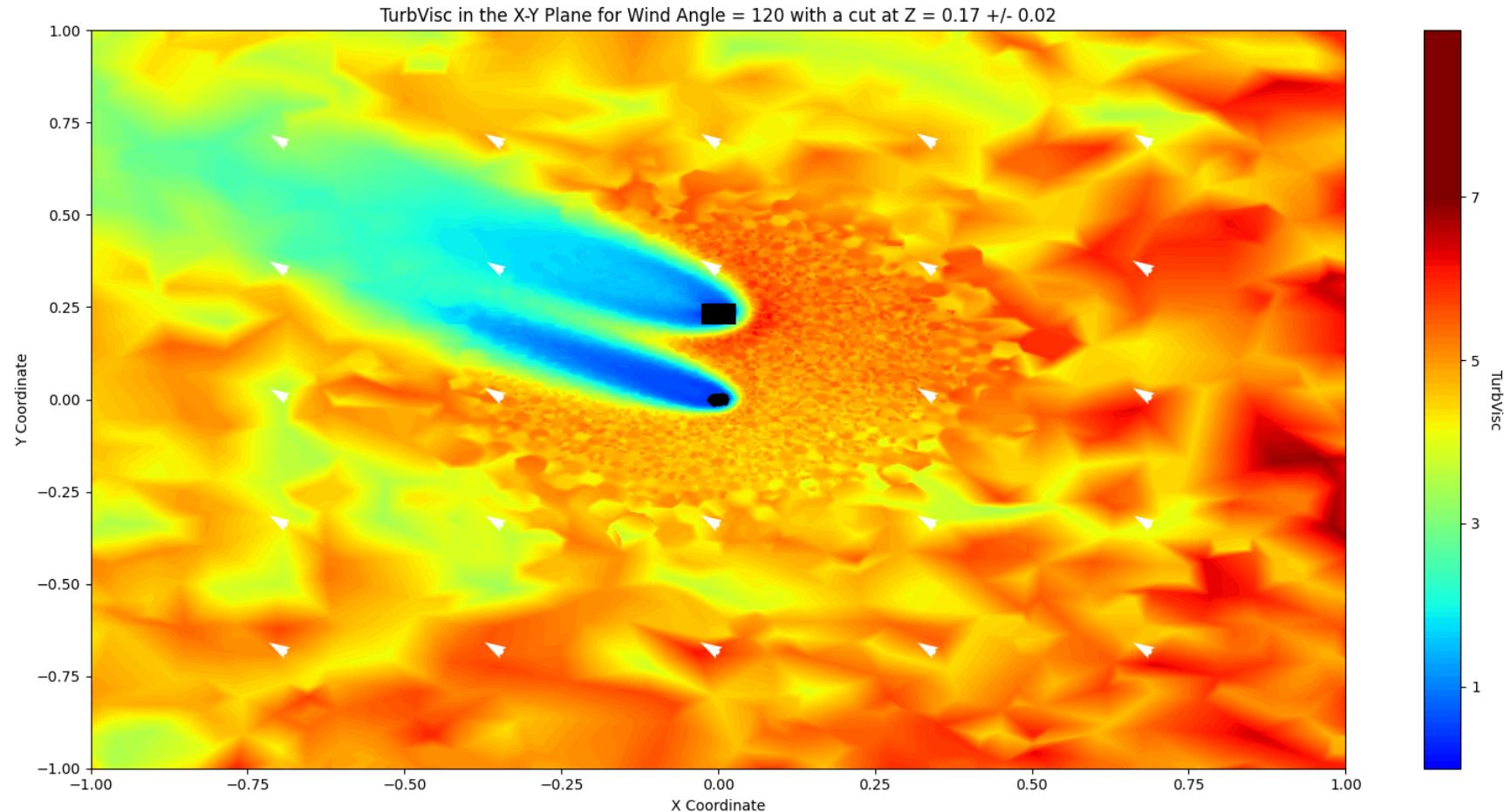
Data Plots – wind angle = 60



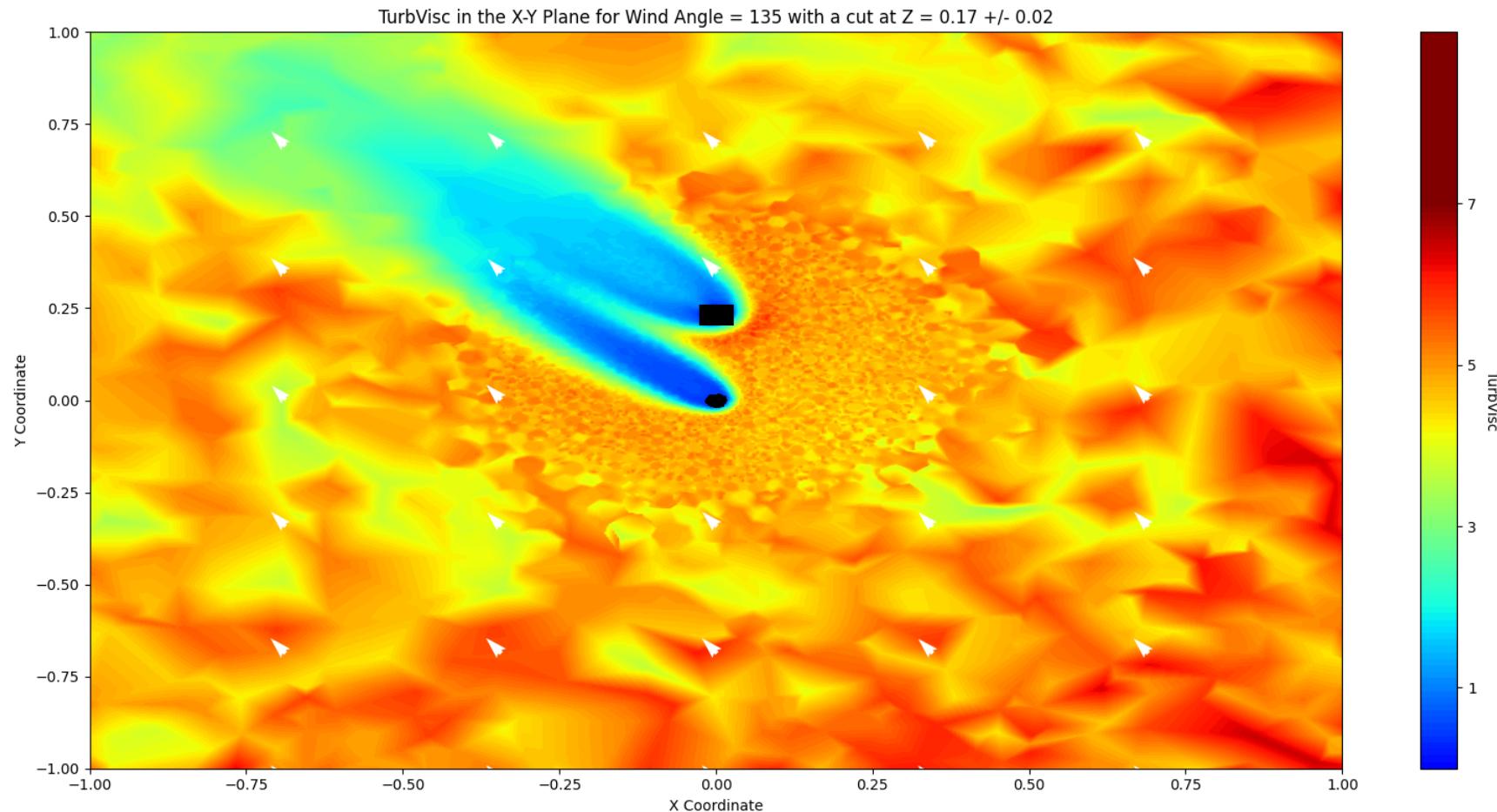
Data Plots – wind angle = 90



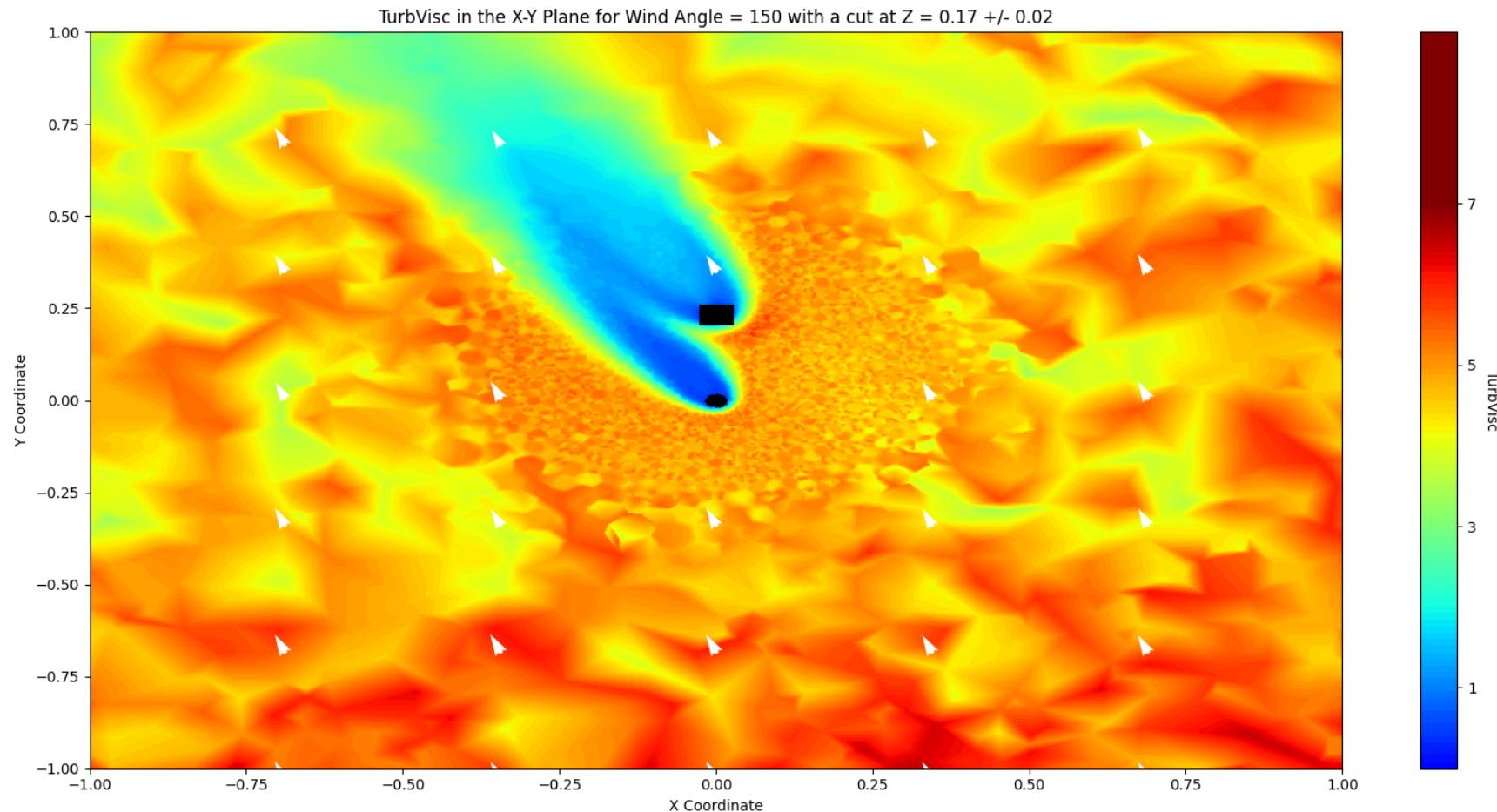
Data Plots – wind angle = 120



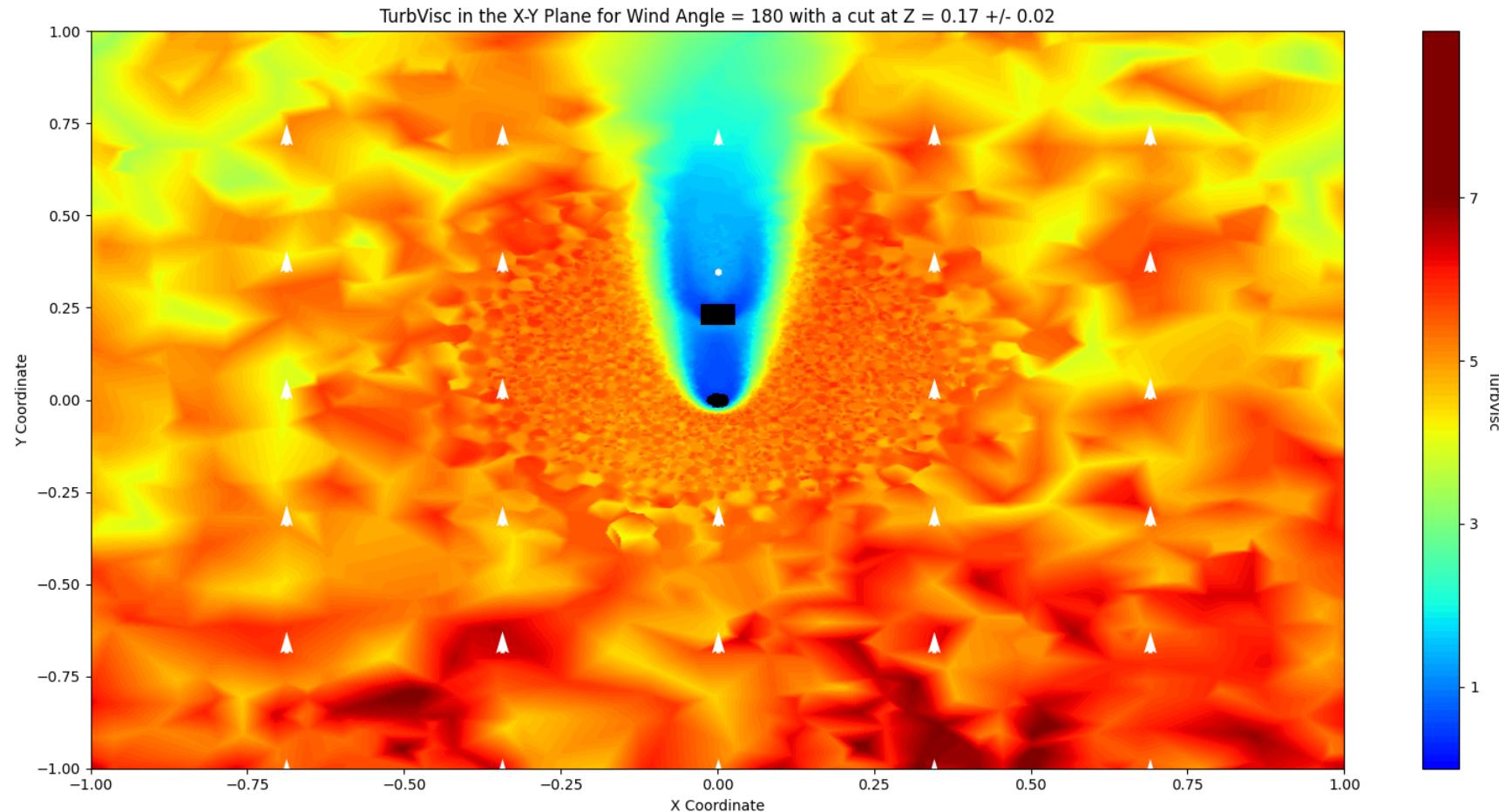
Data Plots – wind angle = 135



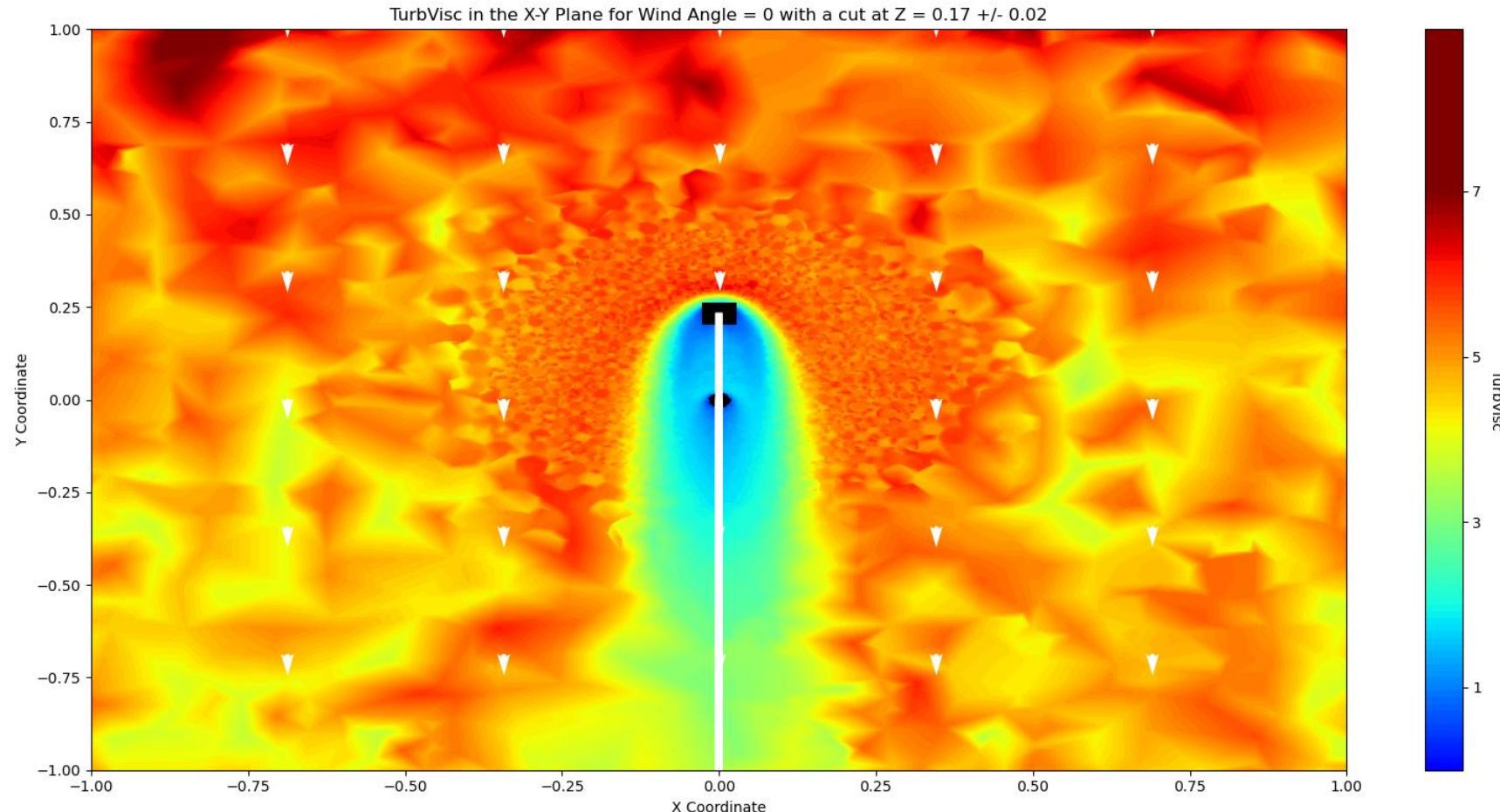
Data Plots – wind angle = 150



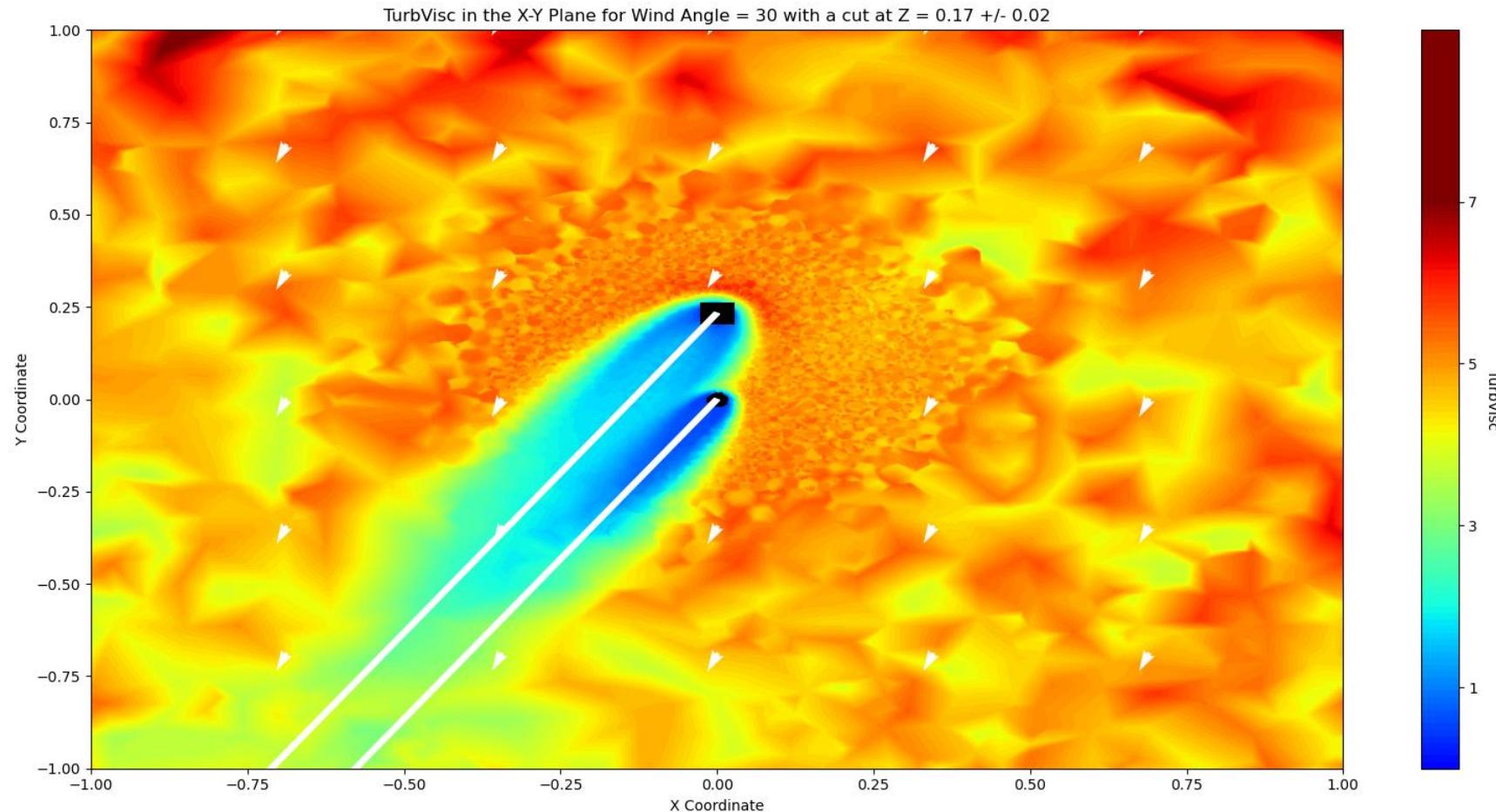
Data Plots – wind angle = 180



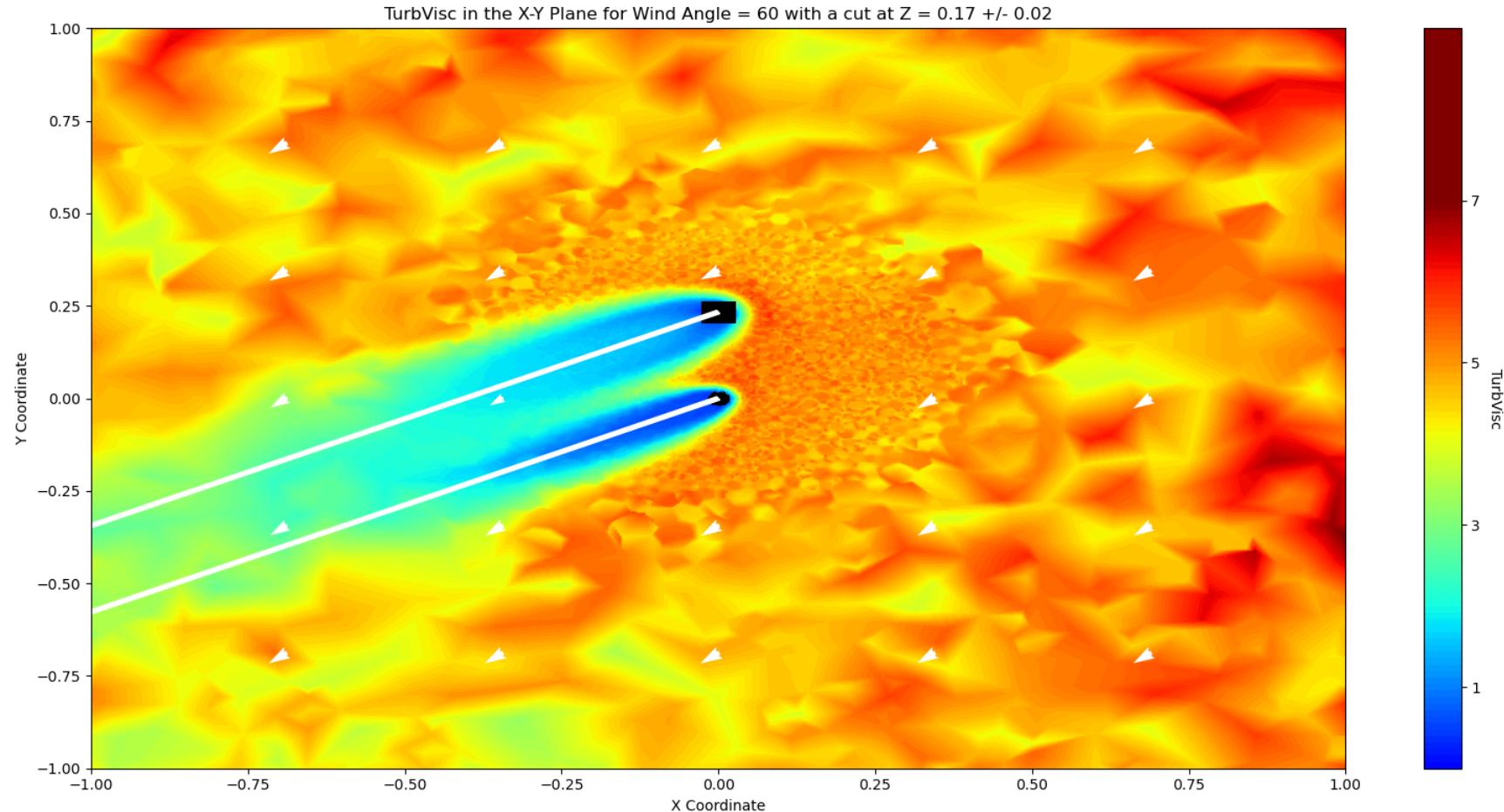
Data Plots – wind angle = 0



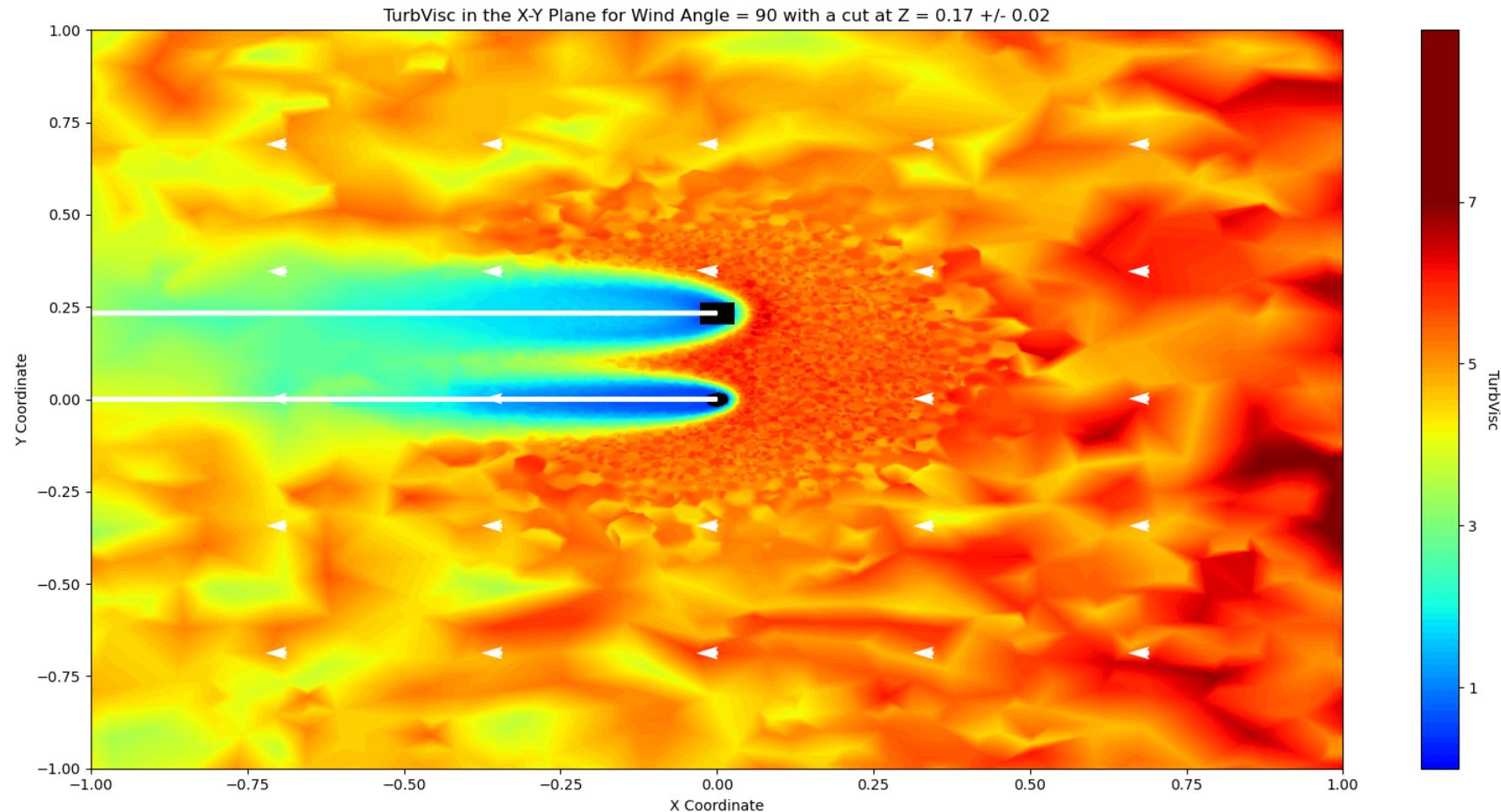
Data Plots – wind angle = 30



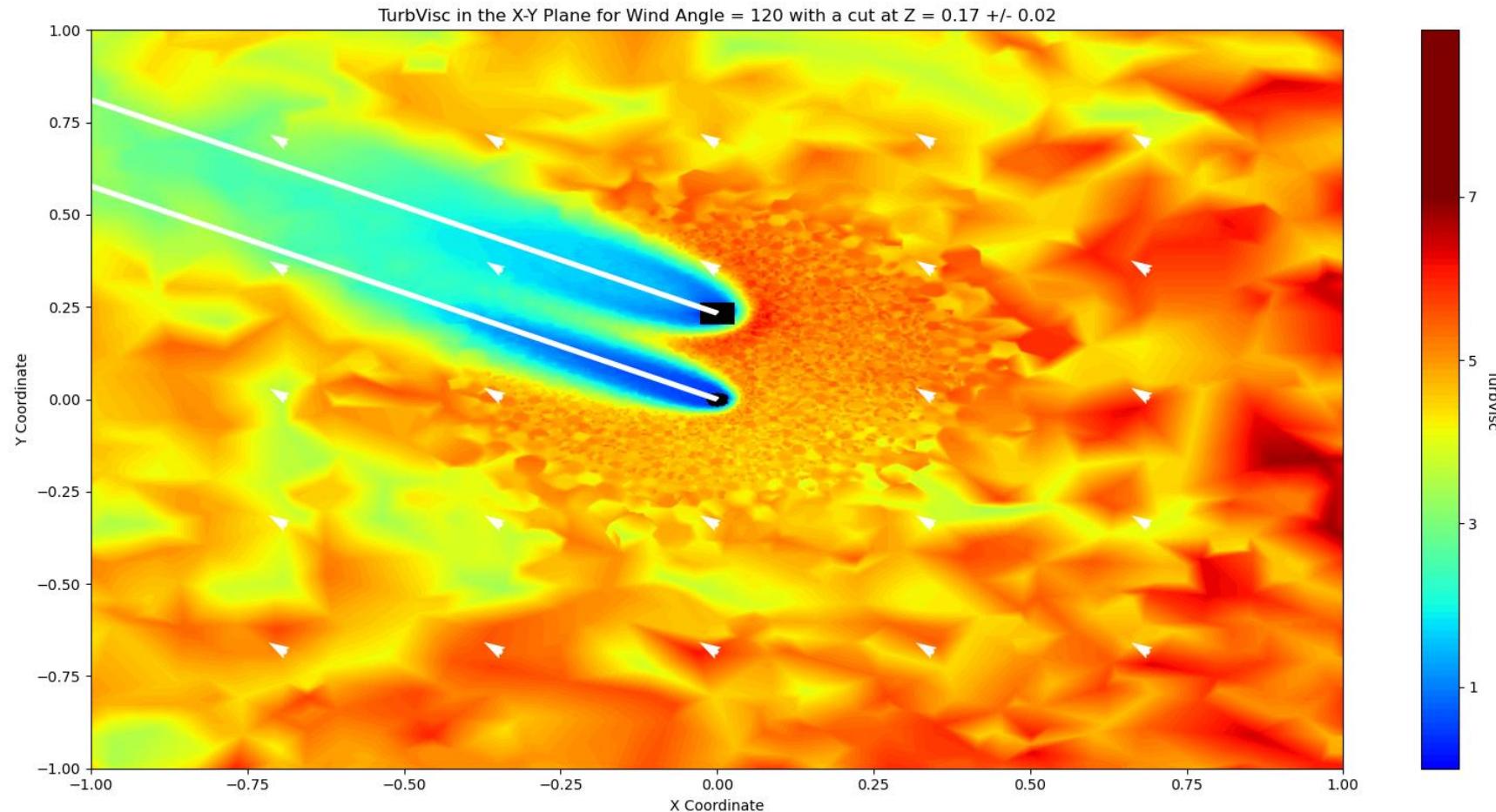
Data Plots – wind angle = 60



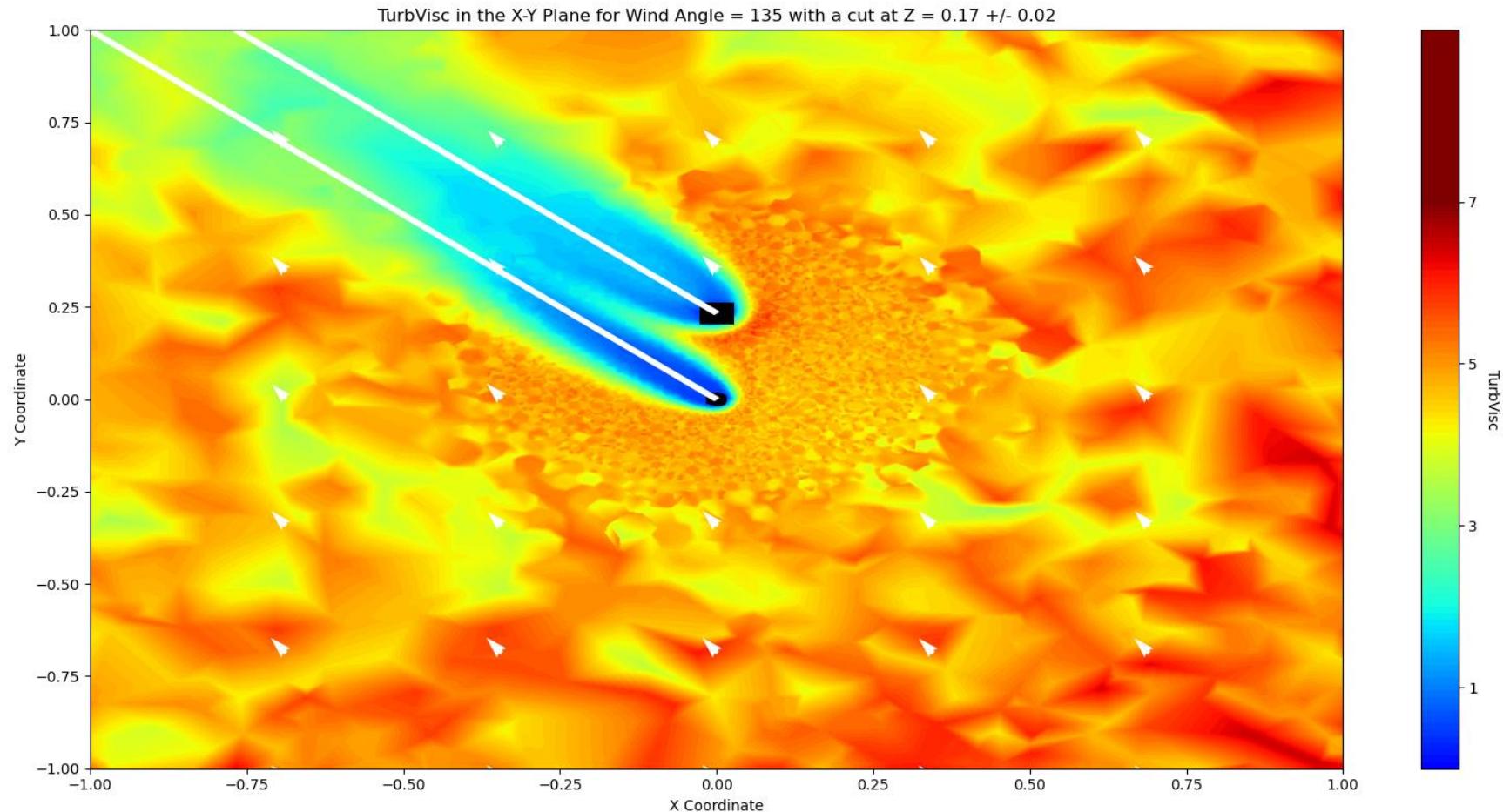
Data Plots – wind angle = 90



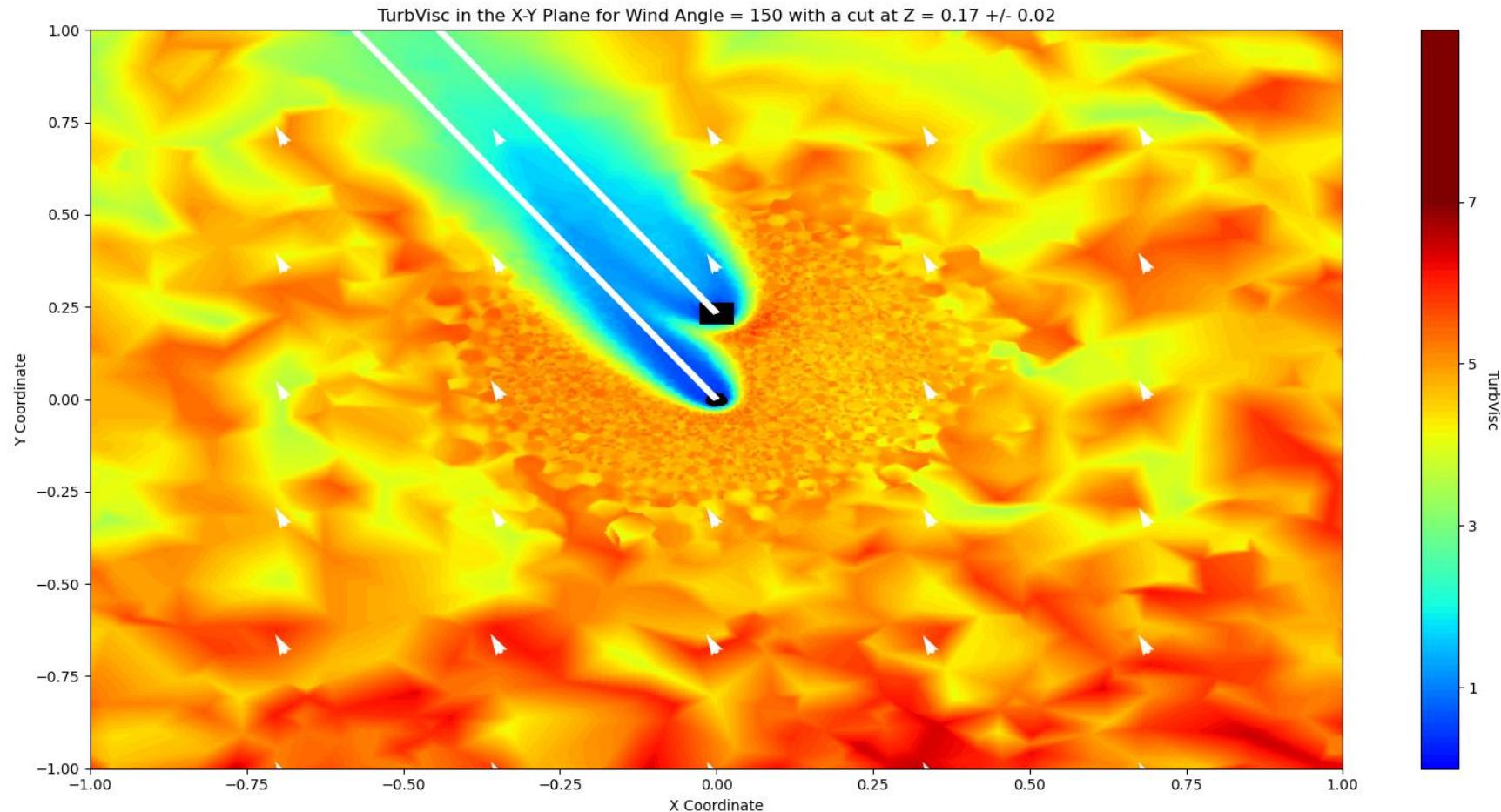
Data Plots – wind angle = 120



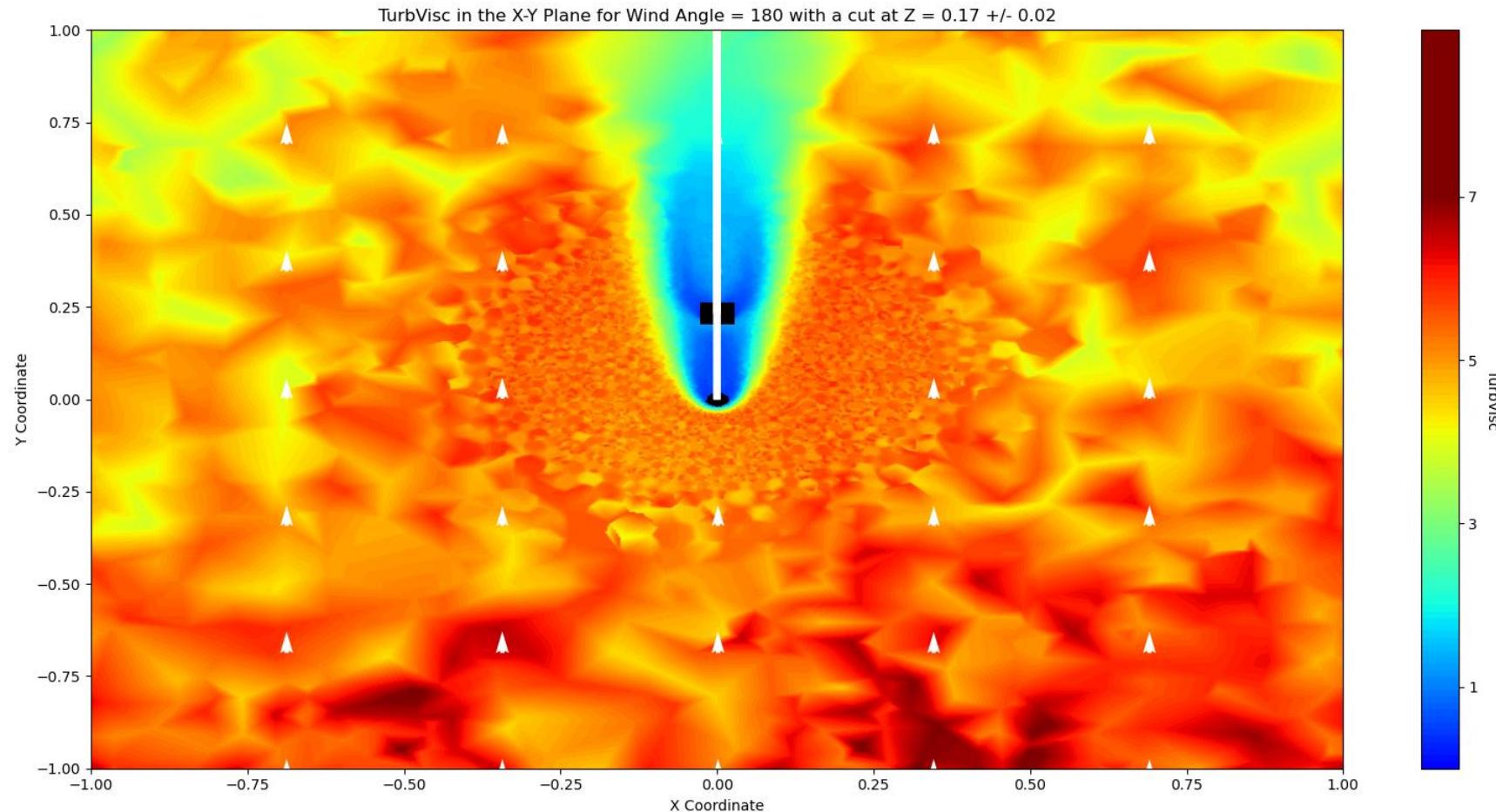
Data Plots – wind angle = 135



Data Plots – wind angle = 150



Data Plots – wind angle = 180



Scripts v3 – Preliminary Results

Some Updates to v3

- 1) Option to overlay plots with quiver arrows in configuration file
- 2) Option to plot for any angle in configuration file
- 3) Number of neurons customizable from configuration file
- 4) Type of activation function customizable
- 5) Type of scaler customizable
- 6) Option to plot Turbulent Viscosity (with directional arrows)
- 7) Custom points for physics loss
- 8) Use of both optimizers (Adam first for an ansatz then LBFGS to fine tune solution)

Some Parameters

Infinite epochs - instead the criteria for stopping is $\text{loss}_{\{n\}} - \text{loss}_{\{n-1\}} < \epsilon$ for 10 consecutive epochs where n is the epoch number and $\epsilon = 1E-5$ (user defined)

128 Neurons for the PINN unless otherwise specified

We have the data for 8 angles, [0, 30, 60, 90, 120, 135, 150, 180] in degrees

We concatenate the data for angles = [0, 30, 60, 90, 120, 150, 180] and then take 99.99% of the dataset with random seed = 42 for training and 0.01% for testing

By using the whole dataset we hope to make the NN learn about wind angle such that the parameters become functions of the wind angle

Then using the trained neural network we predict the data for angle = 135

Progress so far - Data Loss Only
Standard Normal Scalar
(Adam Optimizer)

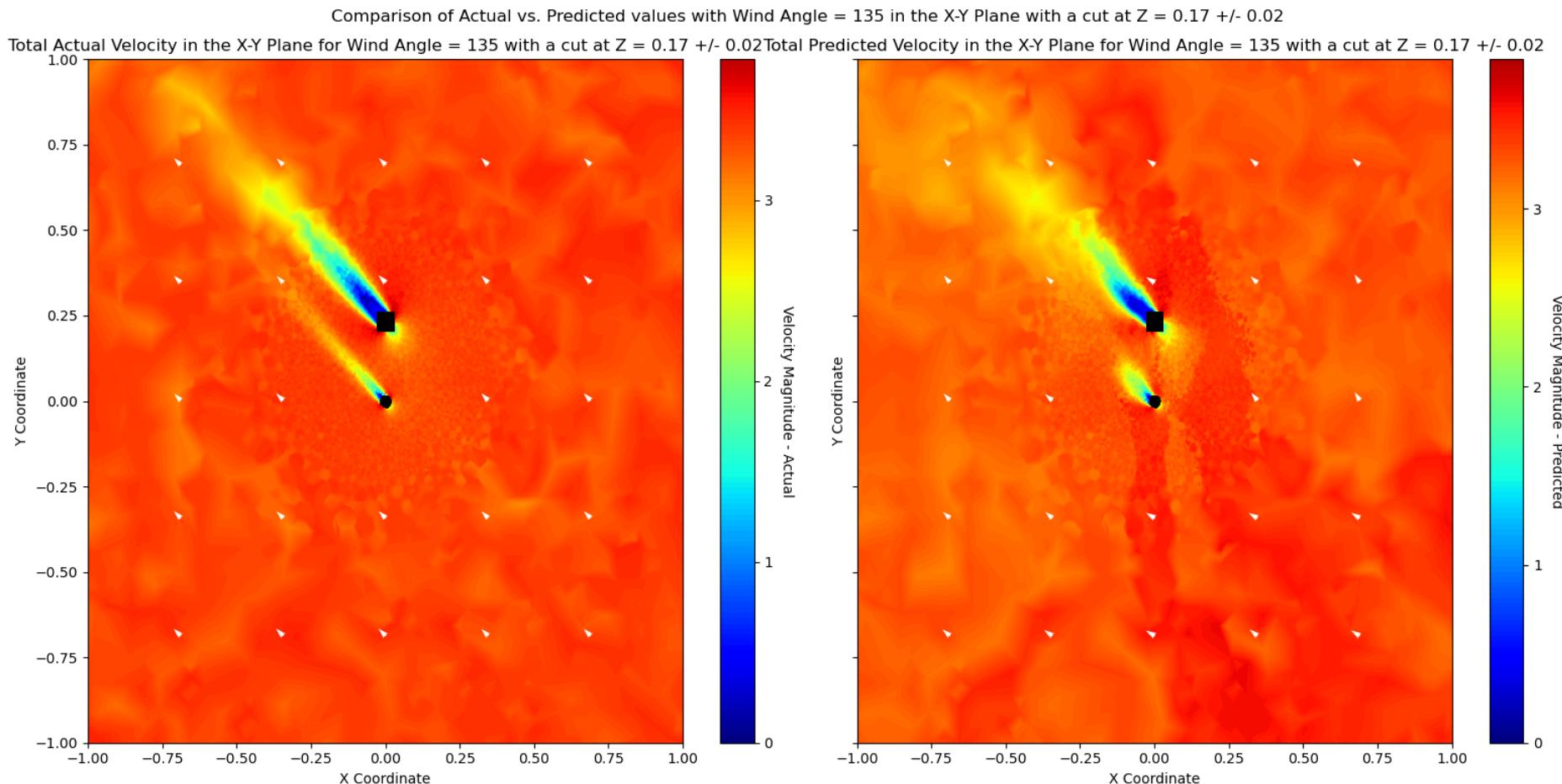
Threshold = 1E-5 (27450 Epochs, not completed), GPU Laptop

Scripts v3 – PREDICTING (135 DEG)

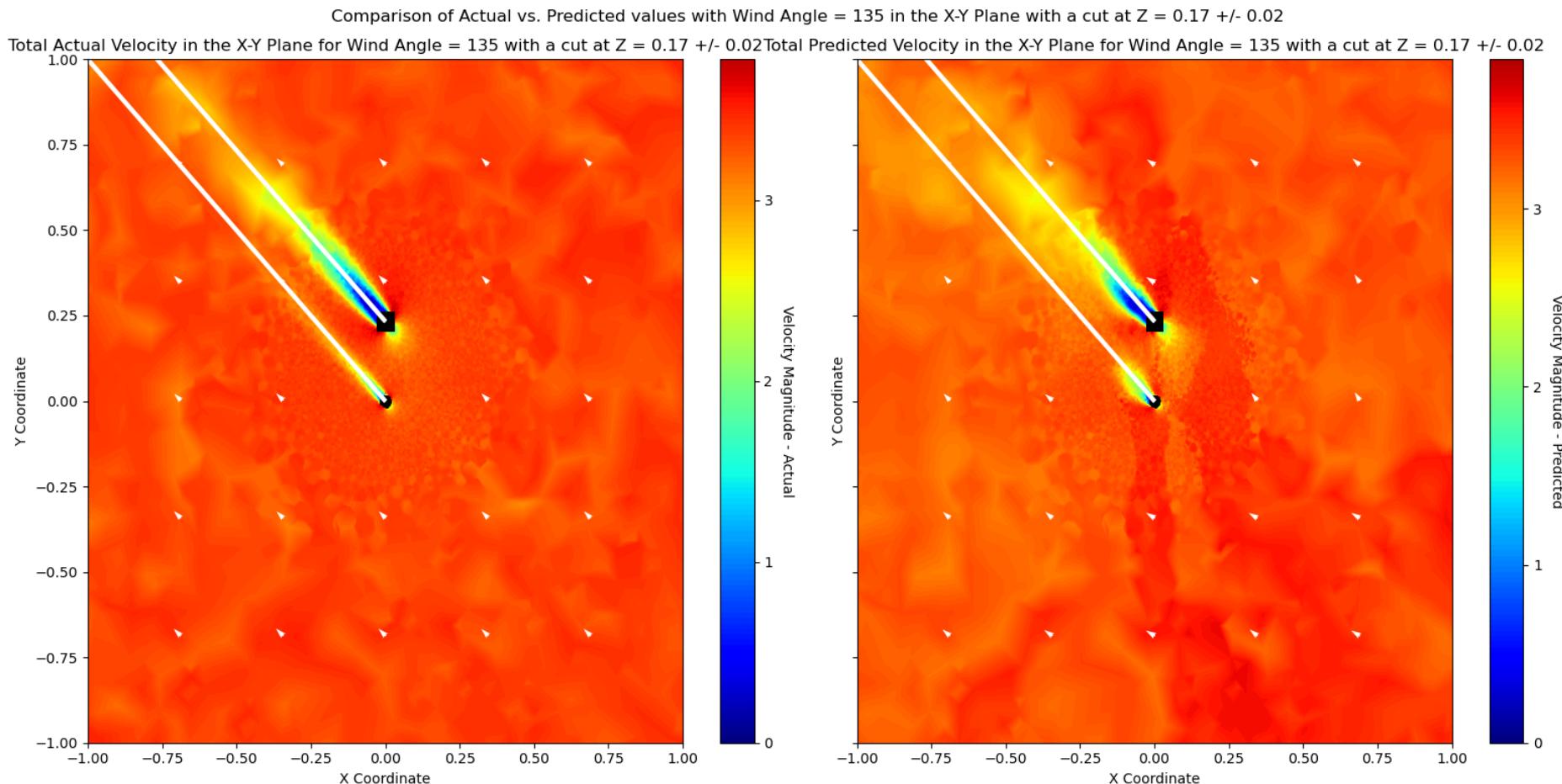
Progress so far - Data Loss Only (Adam Optimizer – Std Normal Scalar)
Threshold = 1E-5 (27450 Epochs, so far...), GPU Laptop
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	0.948246	0.973779	0.92035	0.439028
Velocity:0	0.293232	0.541509	0.472883	0.7123
Velocity:1	0.248911	0.498909	0.429775	0.758113
Velocity:2	0.002565	0.050644	0.021786	0.9216
TurbVisc	0.201504	0.448892	0.33529	0.998532

Progress so far - Data Loss Only (Adam Optimizer – Std Normal Scalar), Threshold = 1E-5 (27450 Epochs, so far...), GPU Laptop
Predicting Results - X-Y Total Velocity Plot (Angle = 135)

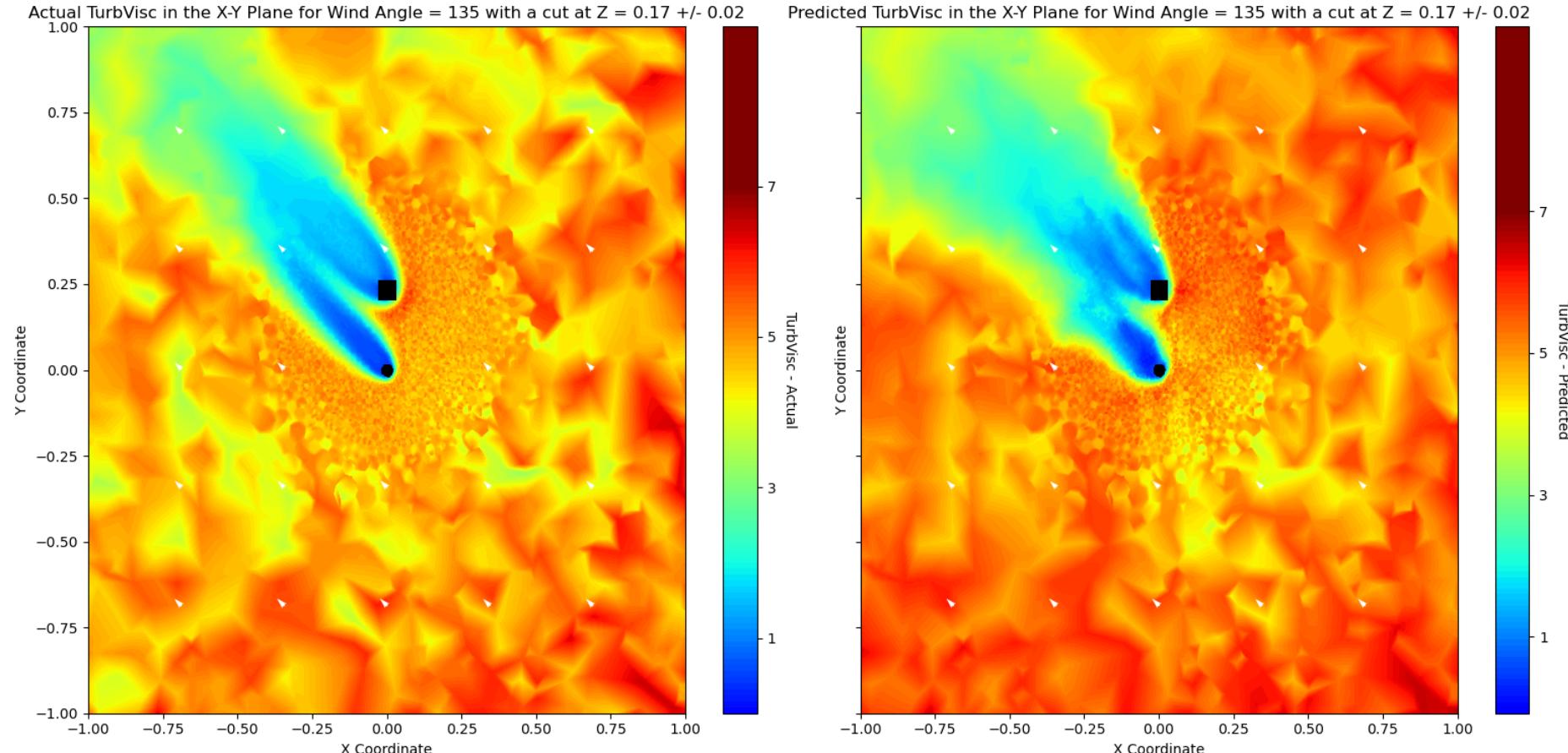


Progress so far - Data Loss Only (Adam Optimizer – Std Normal Scalar), Threshold = 1E-5 (27450 Epochs, so far...), GPU Laptop
Predicting Results - X-Y Total Velocity Plot (Angle = 135)

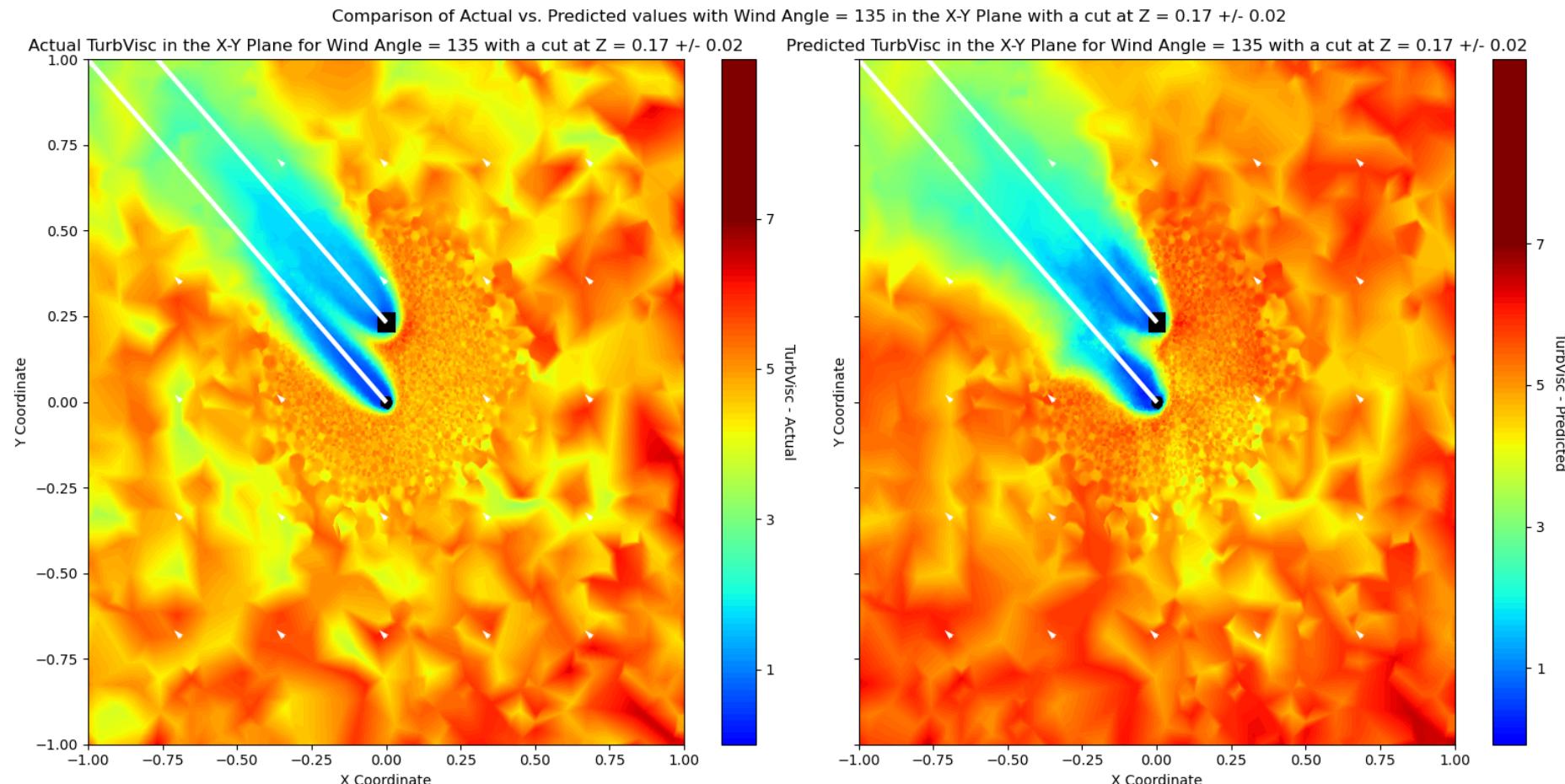


Progress so far - Data Loss Only (Adam Optimizer – Std Normal Scalar), Threshold = 1E-5 (27450 Epochs, so far...), GPU Laptop
Predicting Results - X-Y TurbVisc Plot (Angle = 135)

Comparison of Actual vs. Predicted values with Wind Angle = 135 in the X-Y Plane with a cut at Z = 0.17 +/- 0.02



Progress so far - Data Loss Only (Adam Optimizer – Std Normal Scalar), Threshold = 1E-5 (27450 Epochs, so far...), GPU Laptop
Predicting Results - X-Y TurbVisc Plot (Angle = 135)

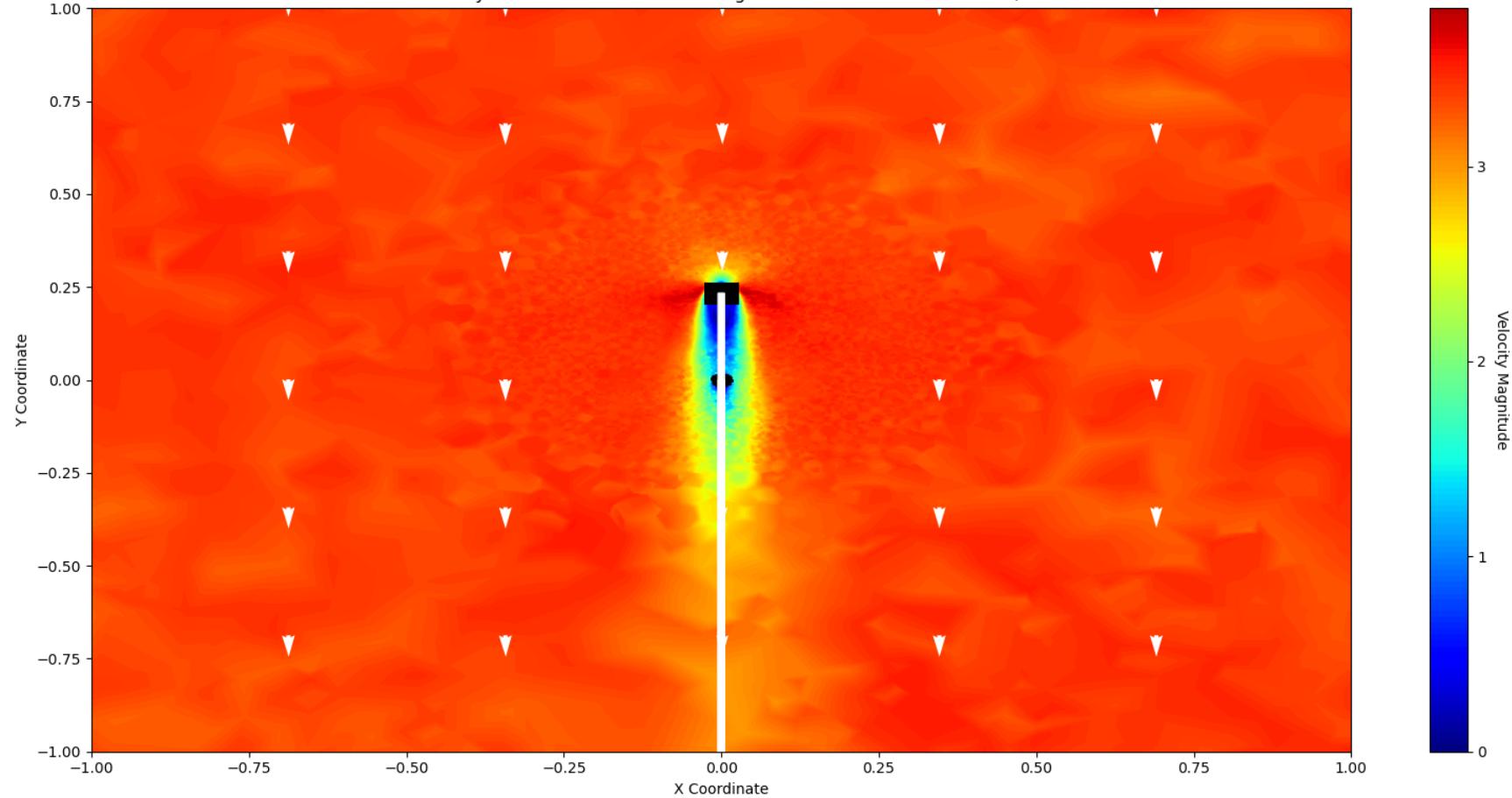


Progress so far - Data Loss Only
Standard Normal Scalar
(Adam Optimizer)

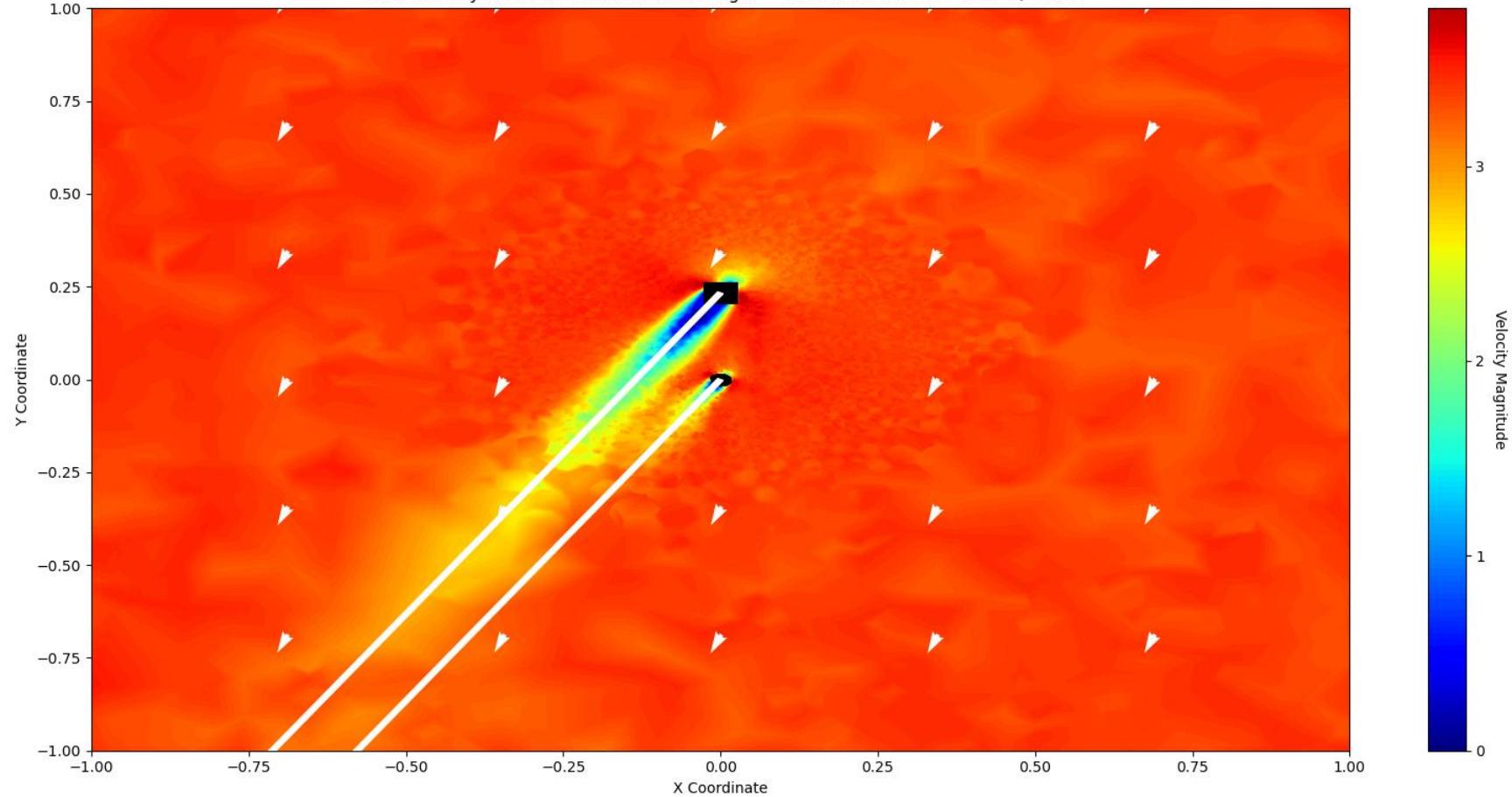
Threshold = 1E-5 (27450 Epochs, not completed), GPU Laptop

Scripts v3 – Plotting Any Angle

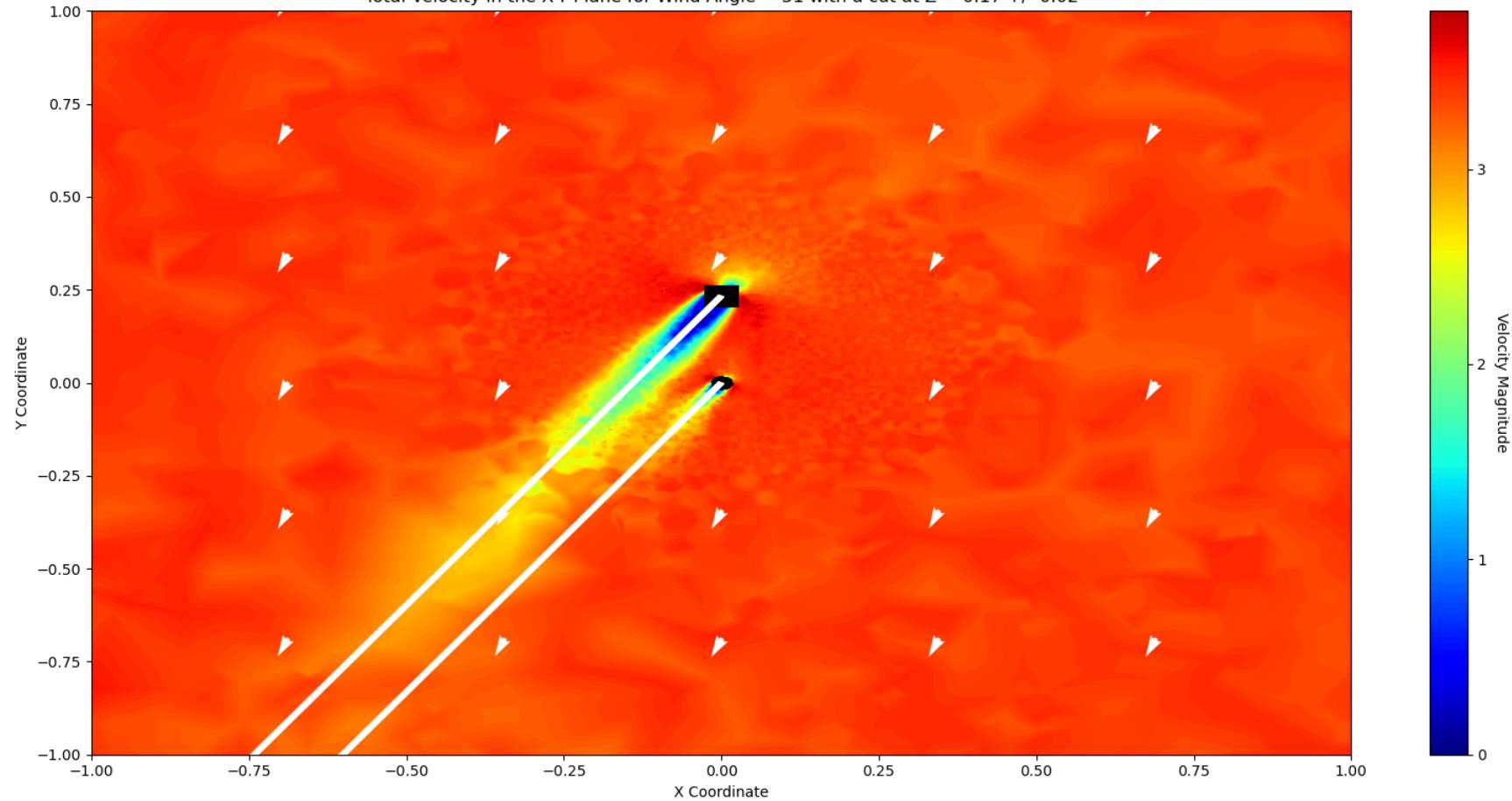
Total Velocity in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



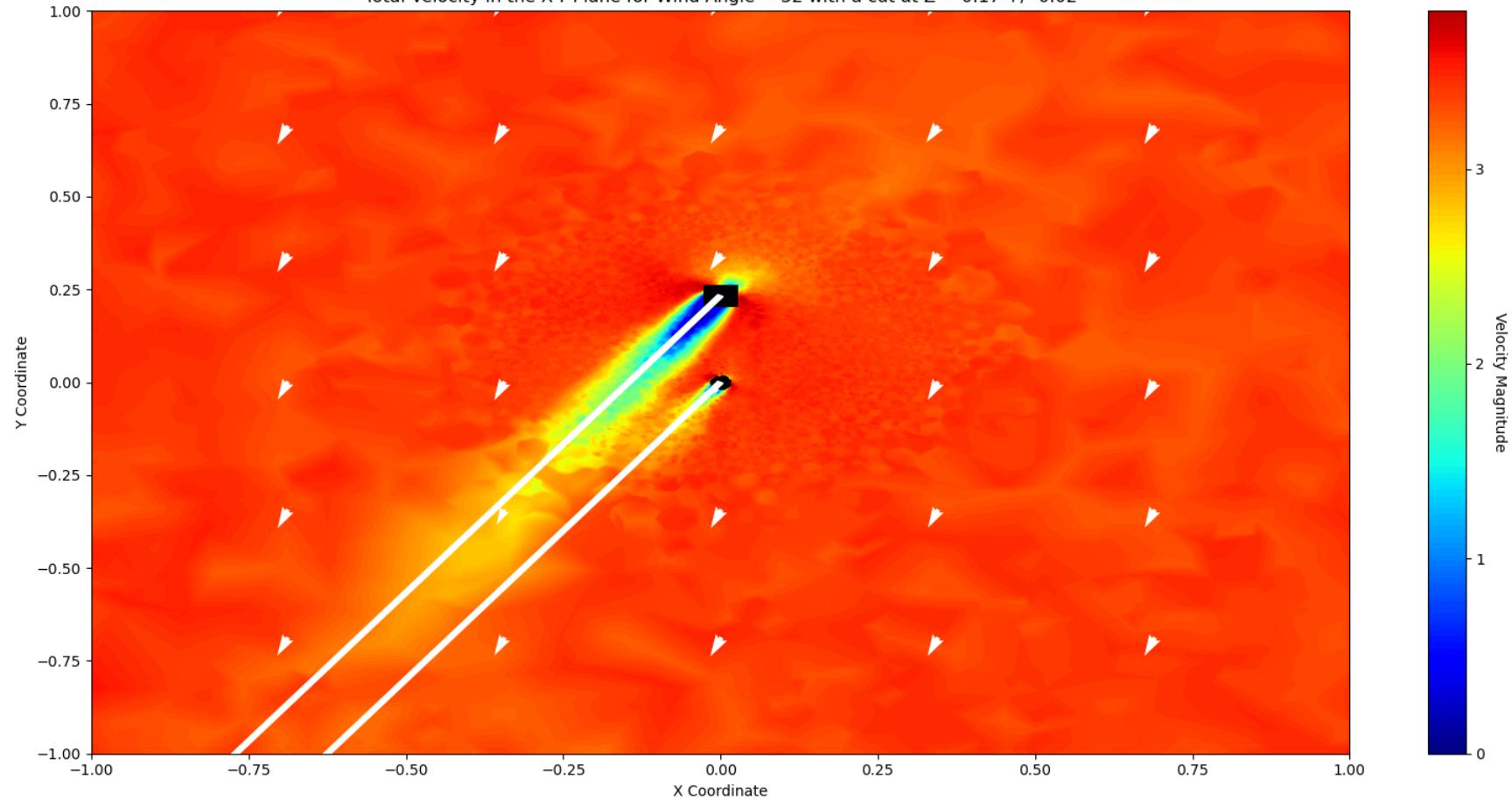
Total Velocity in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



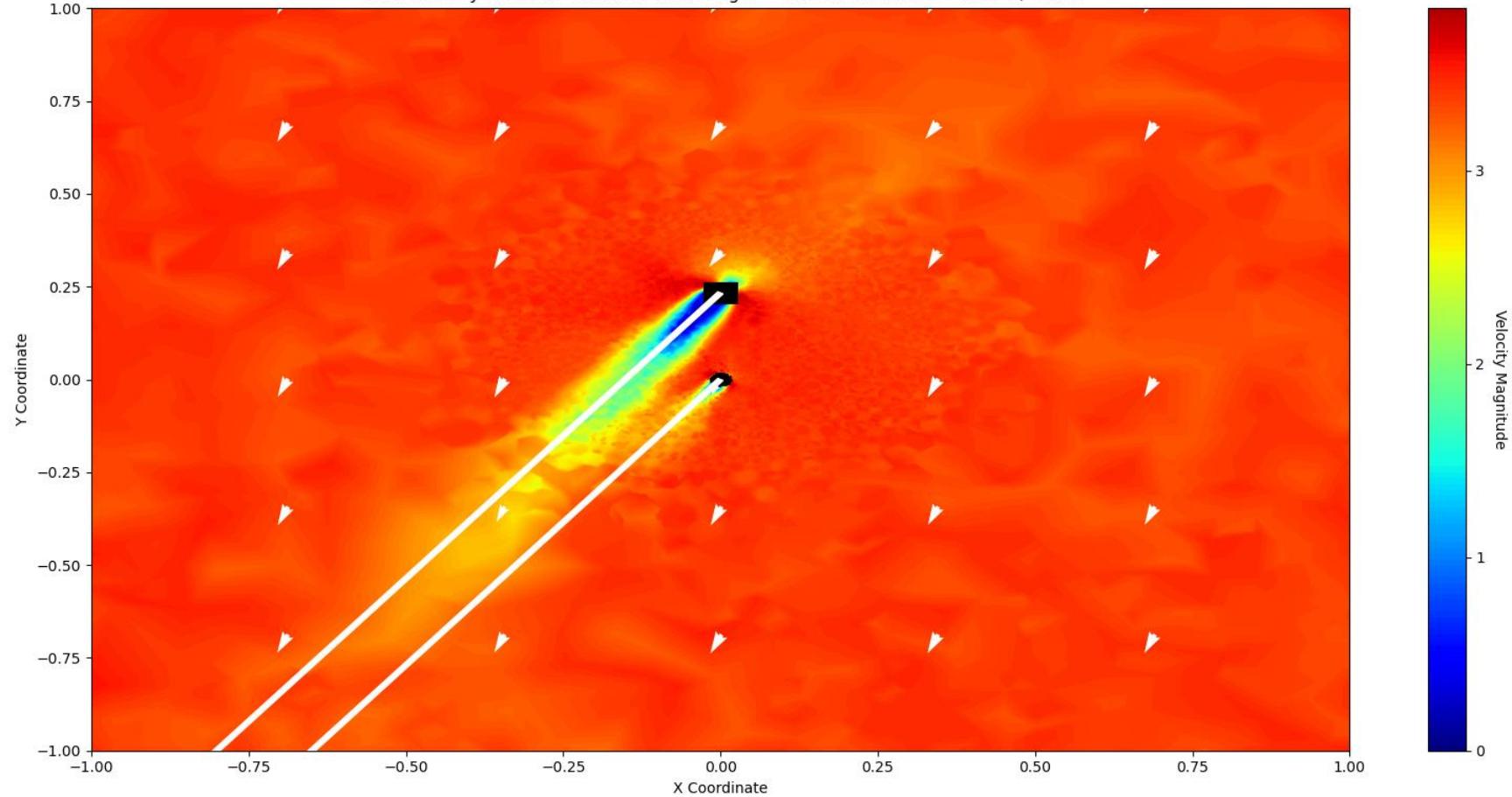
Total Velocity in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



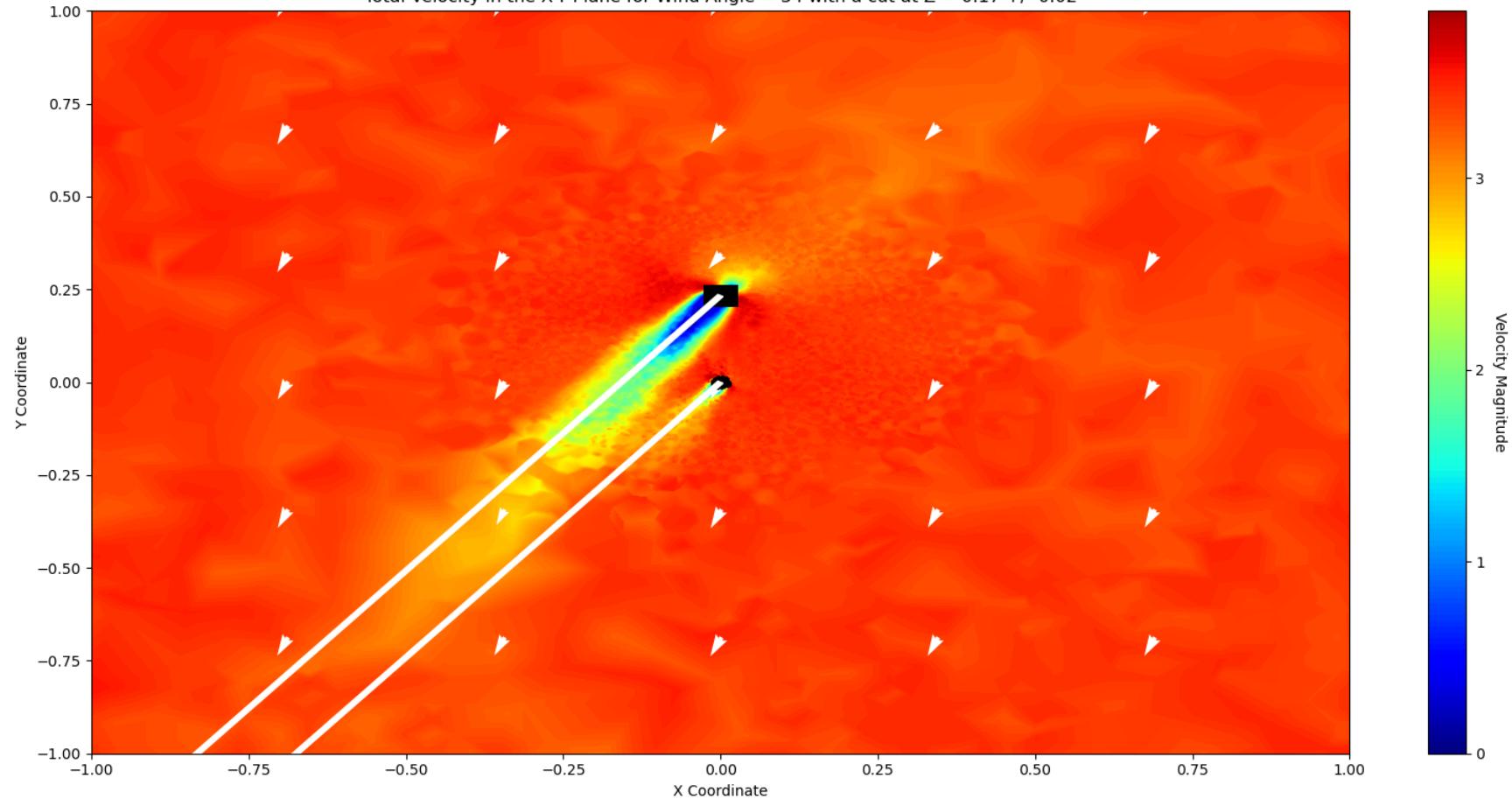
Total Velocity in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



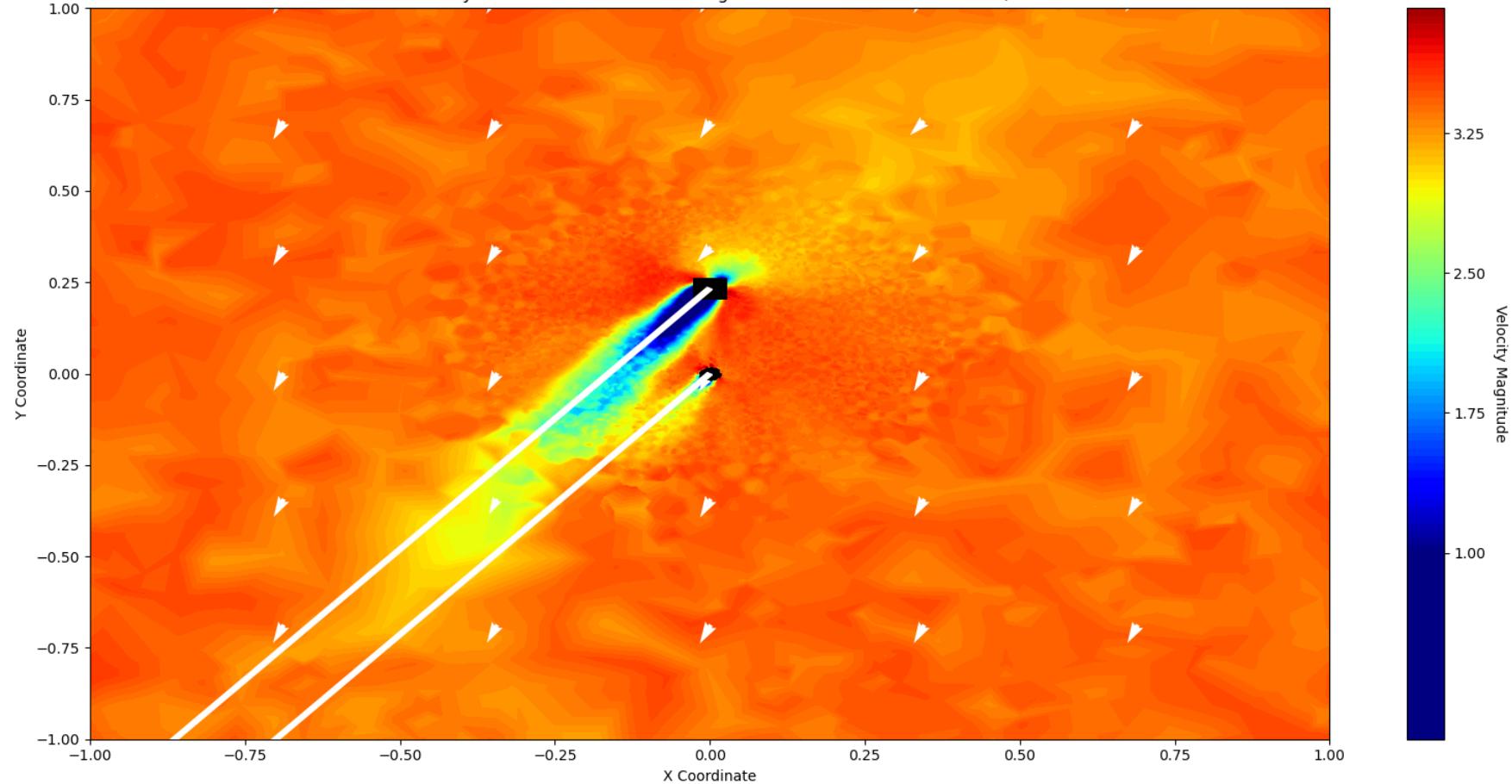
Total Velocity in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



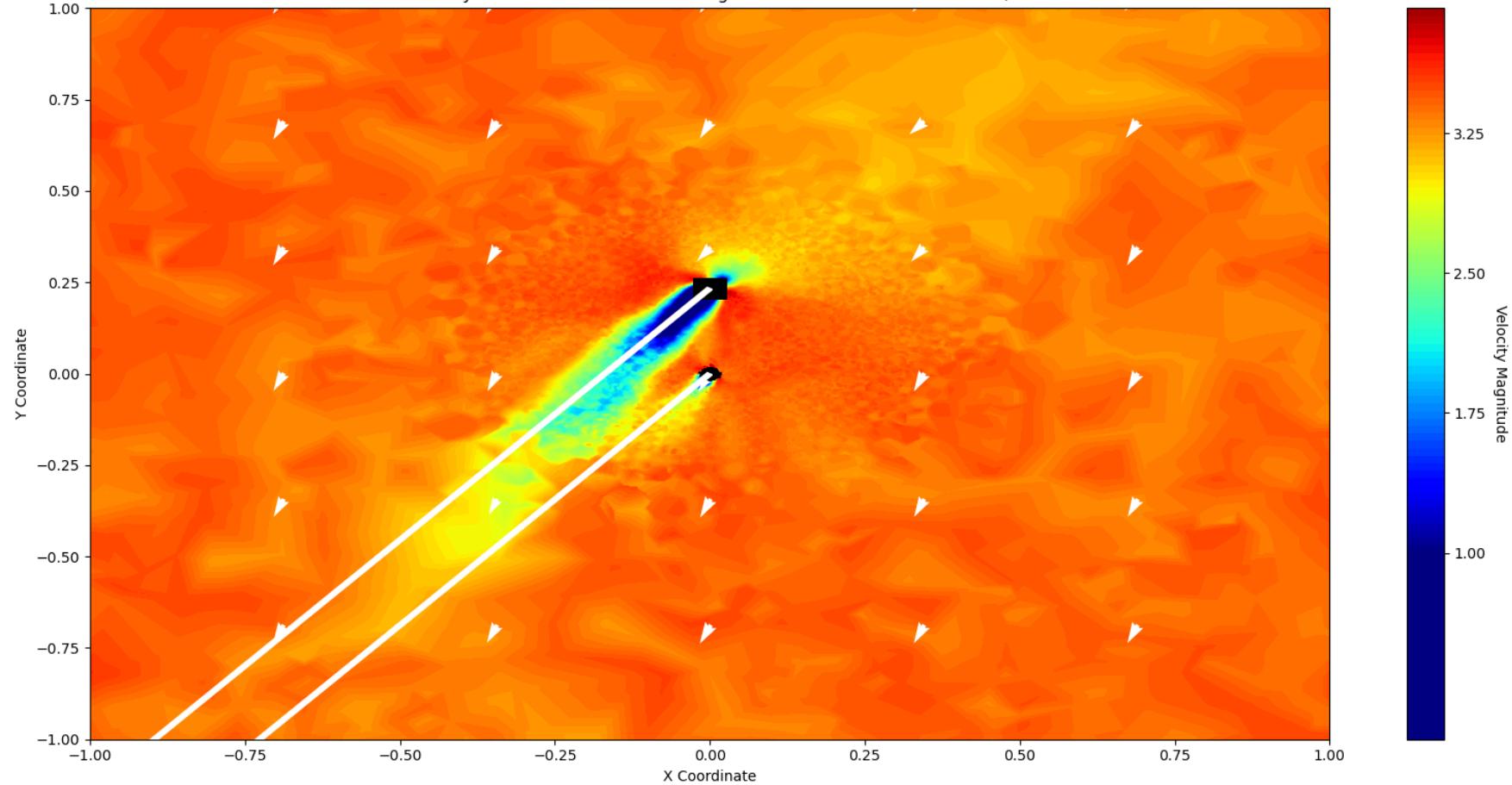
Total Velocity in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



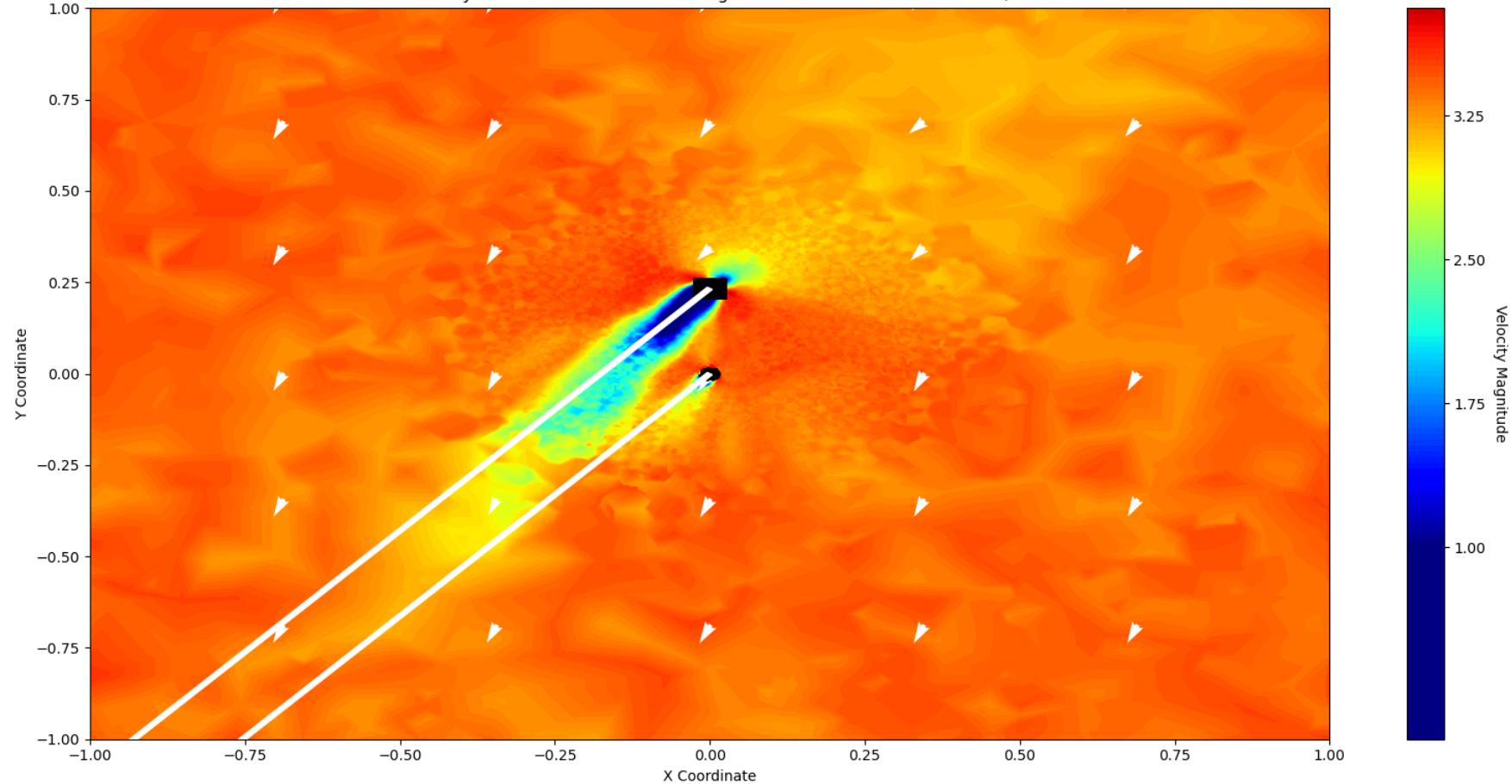
Total Velocity in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



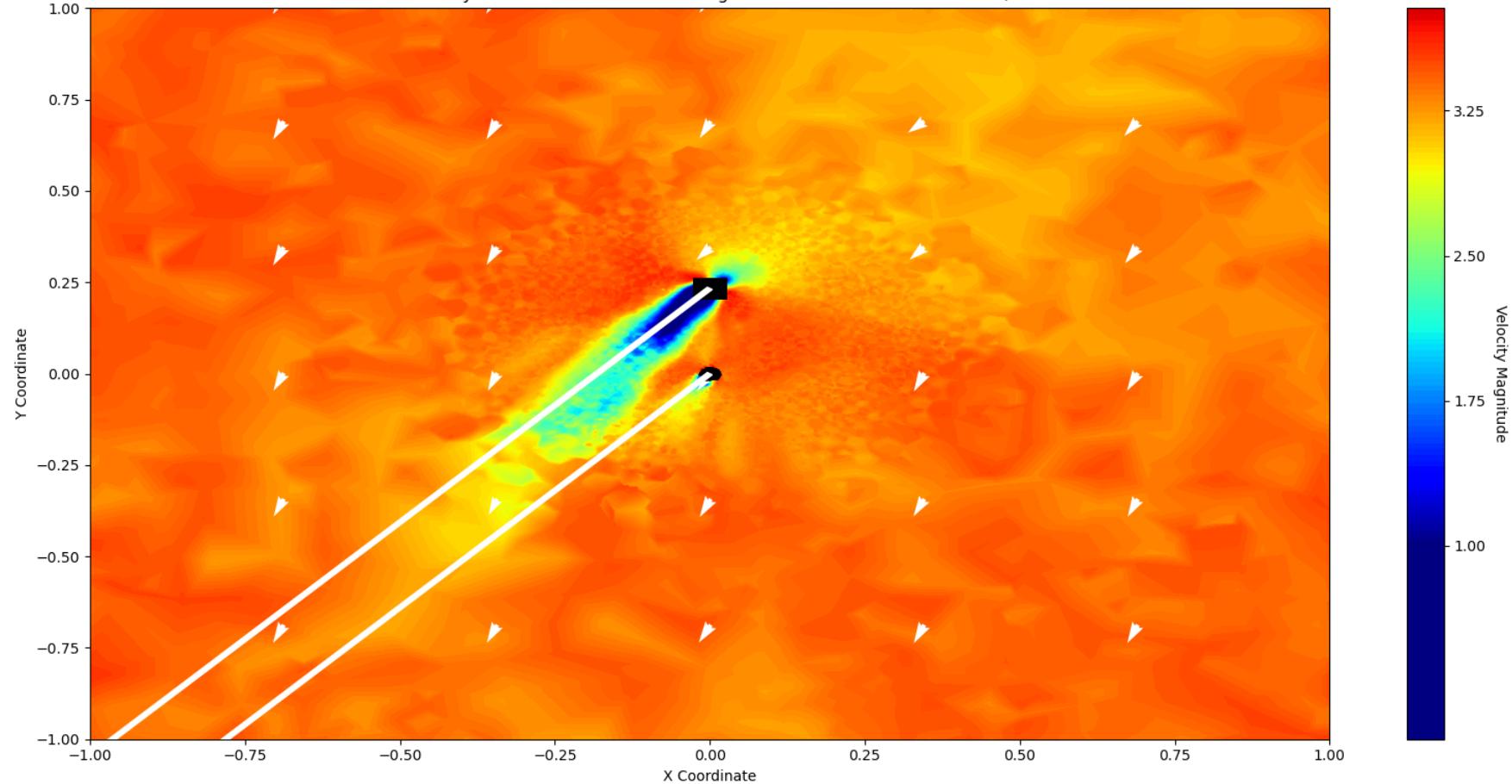
Total Velocity in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



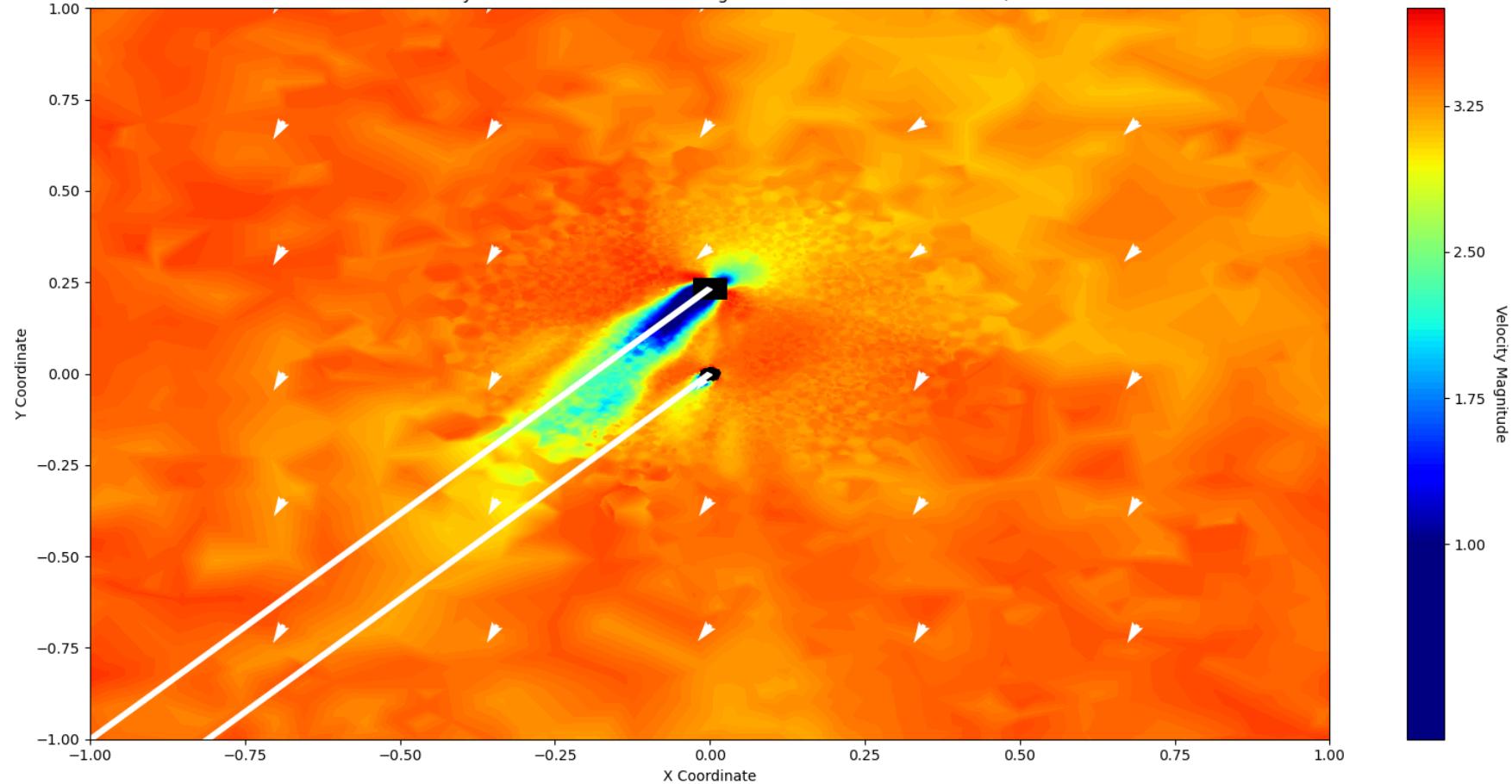
Total Velocity in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



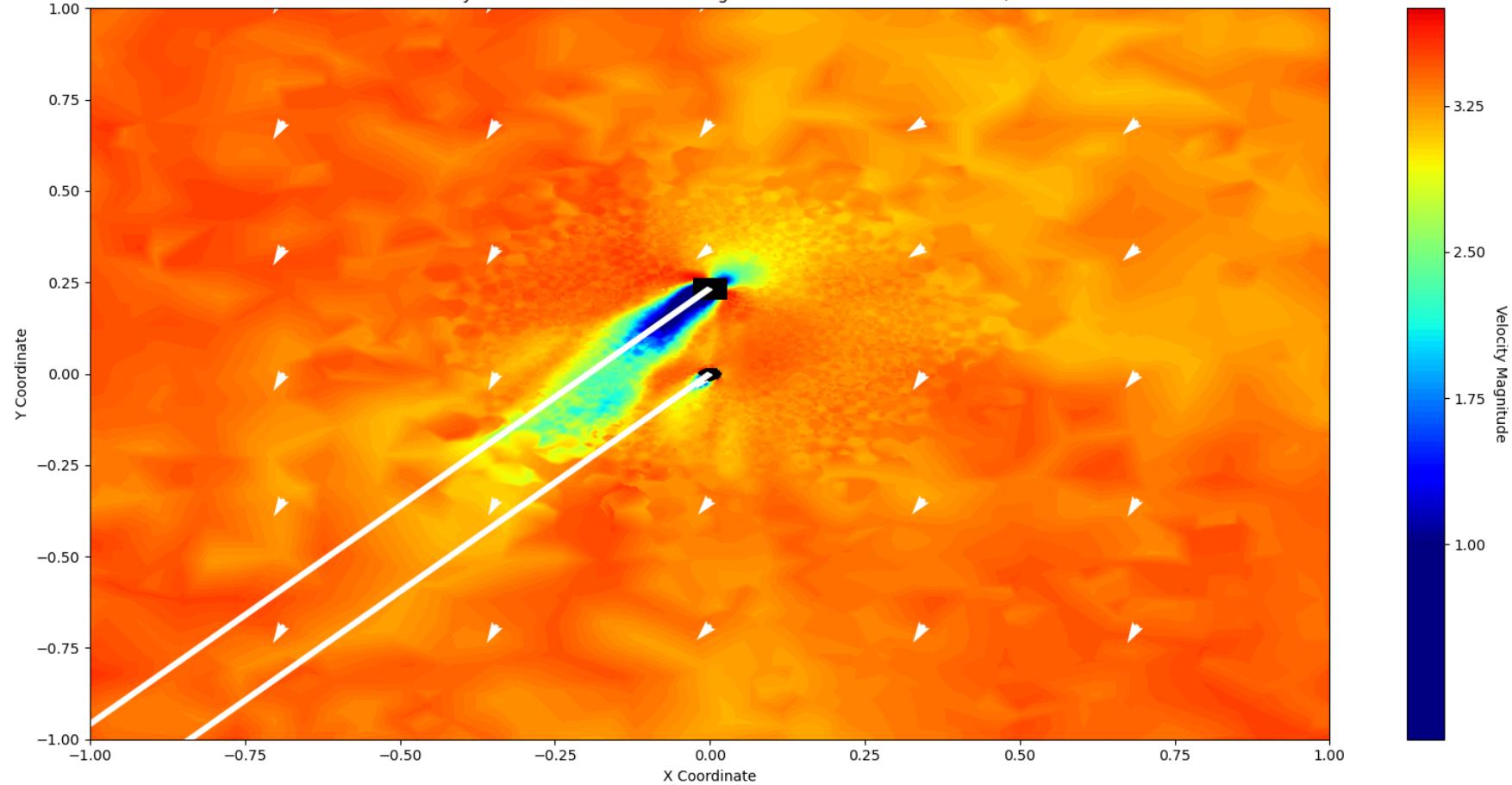
Total Velocity in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



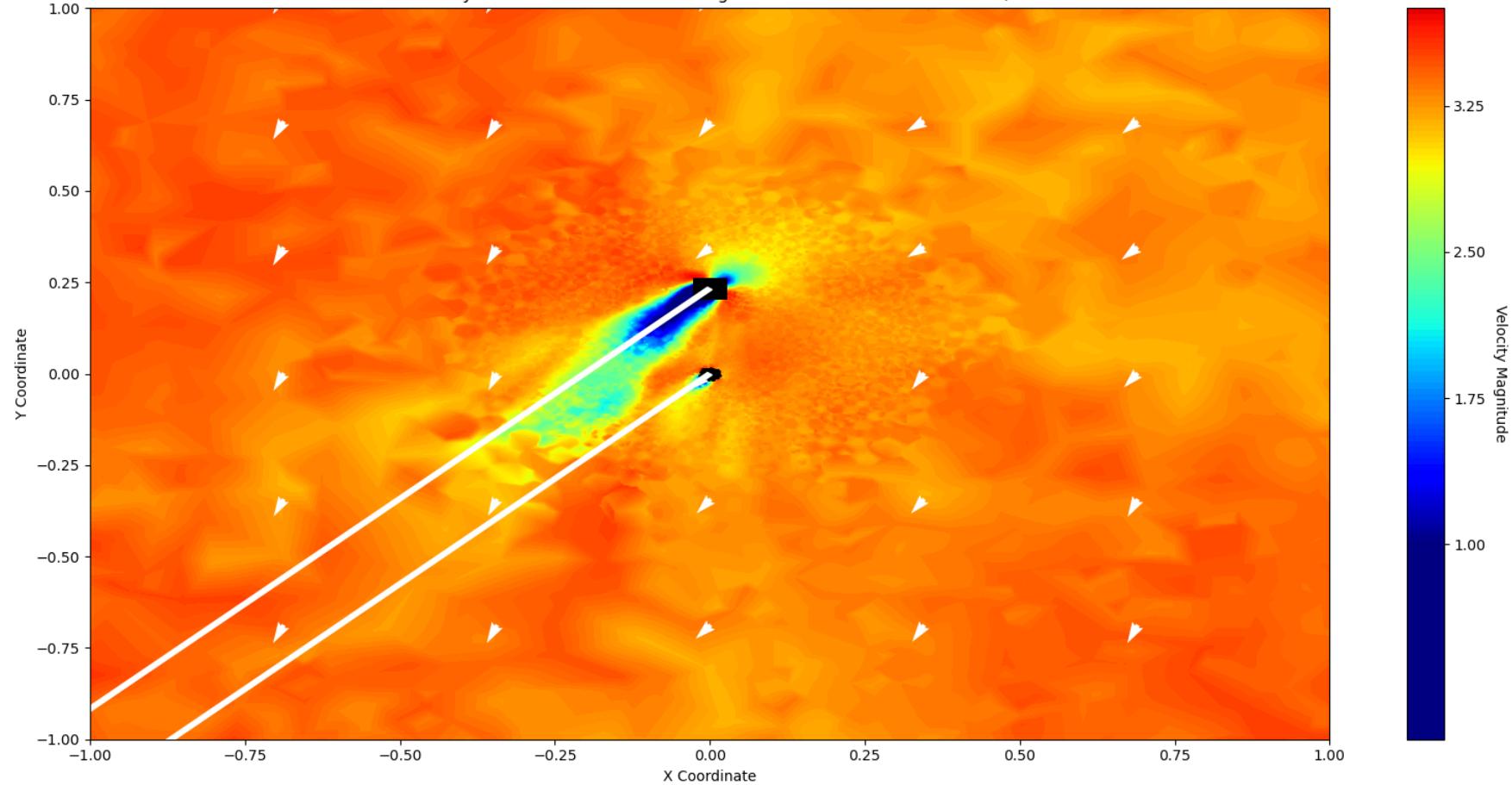
Total Velocity in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



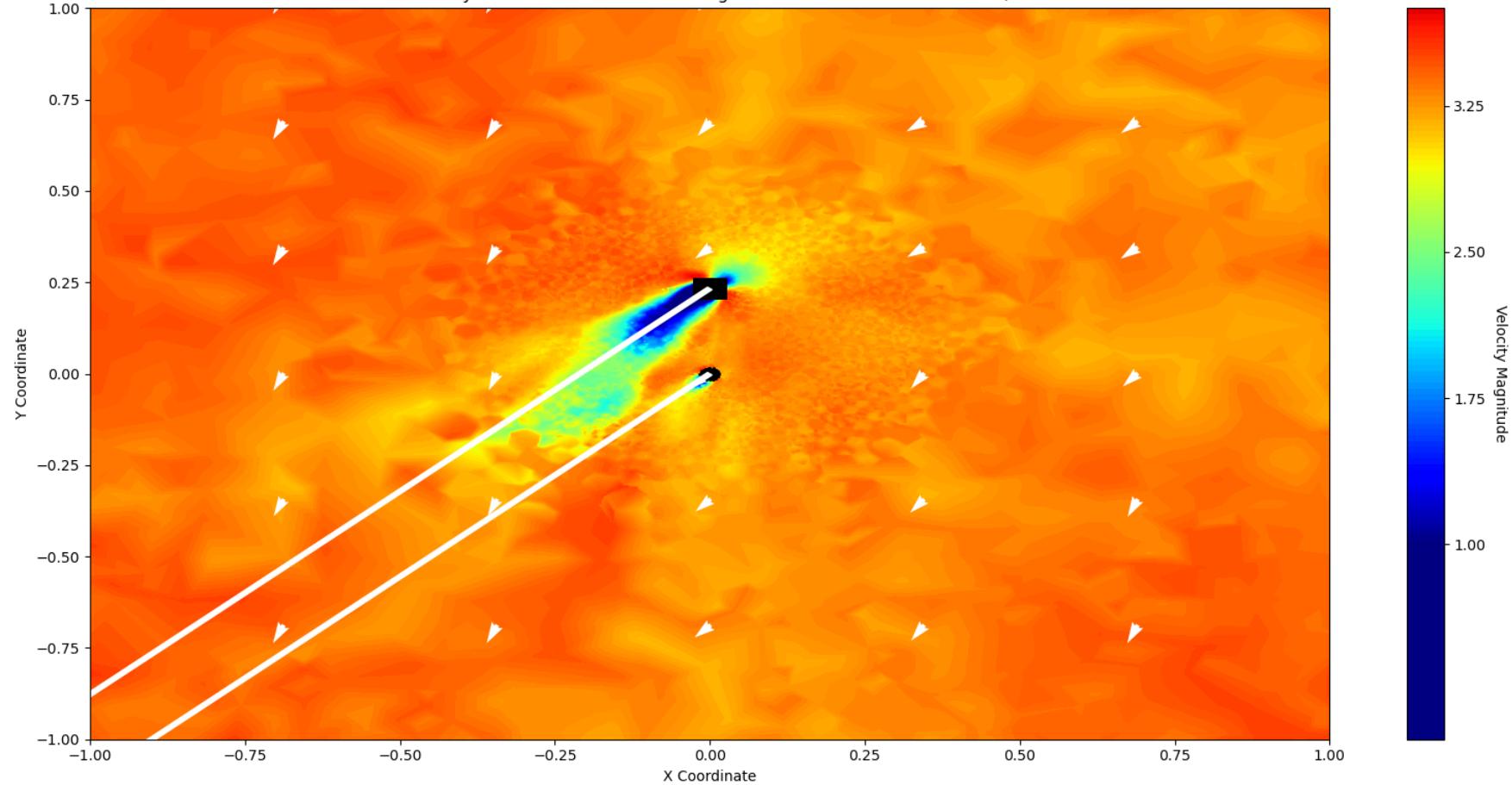
Total Velocity in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



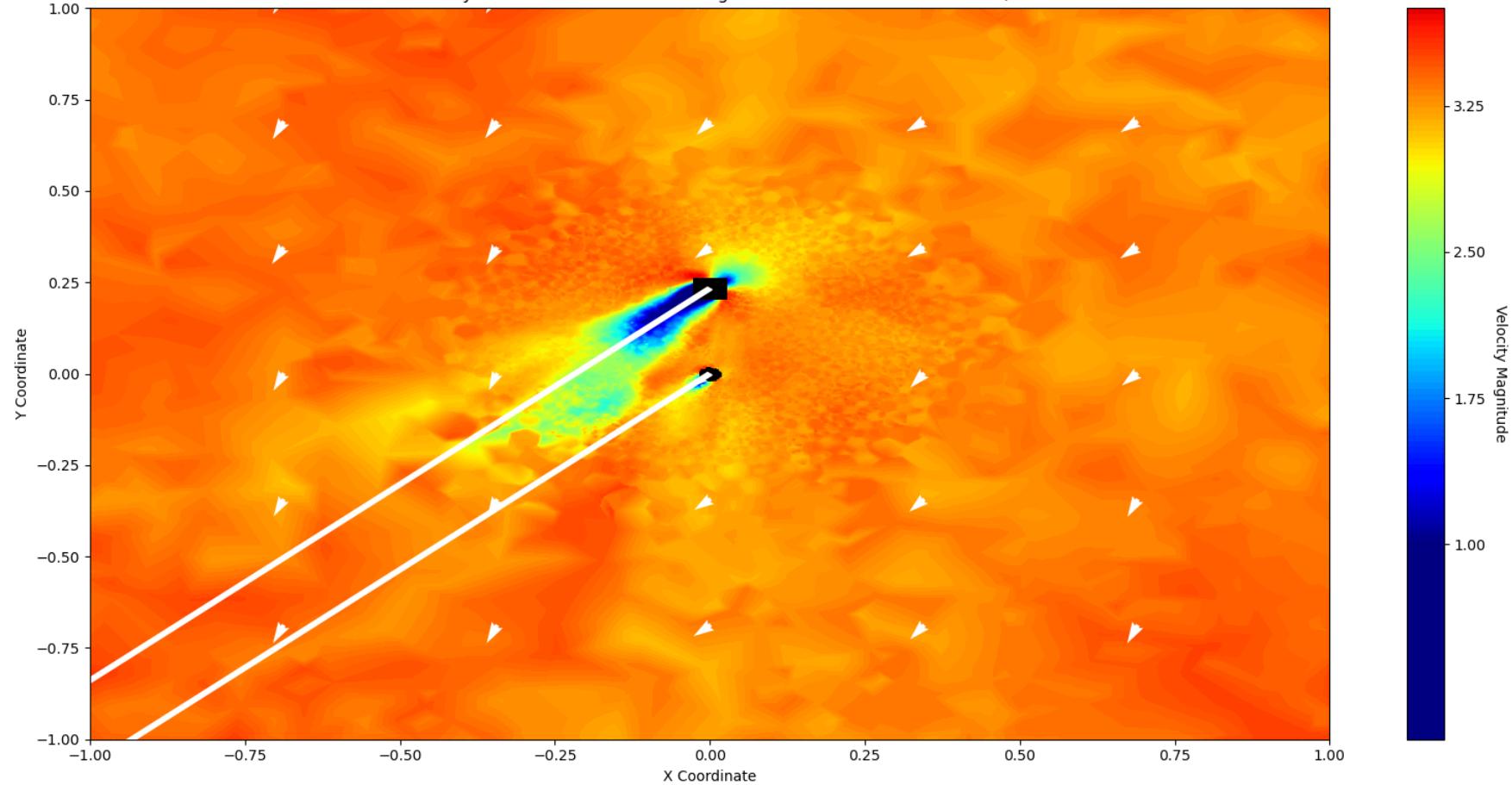
Total Velocity in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



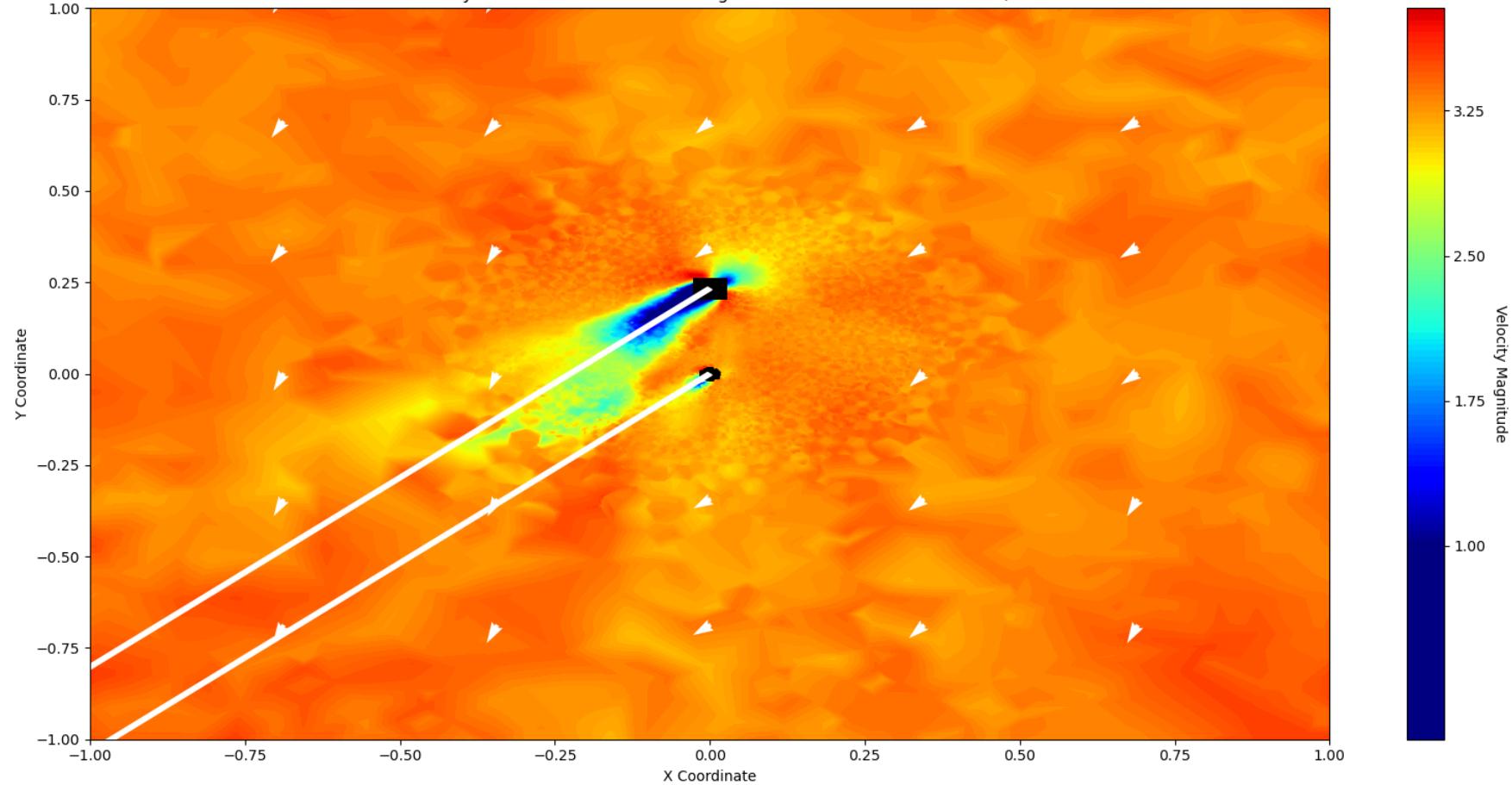
Total Velocity in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



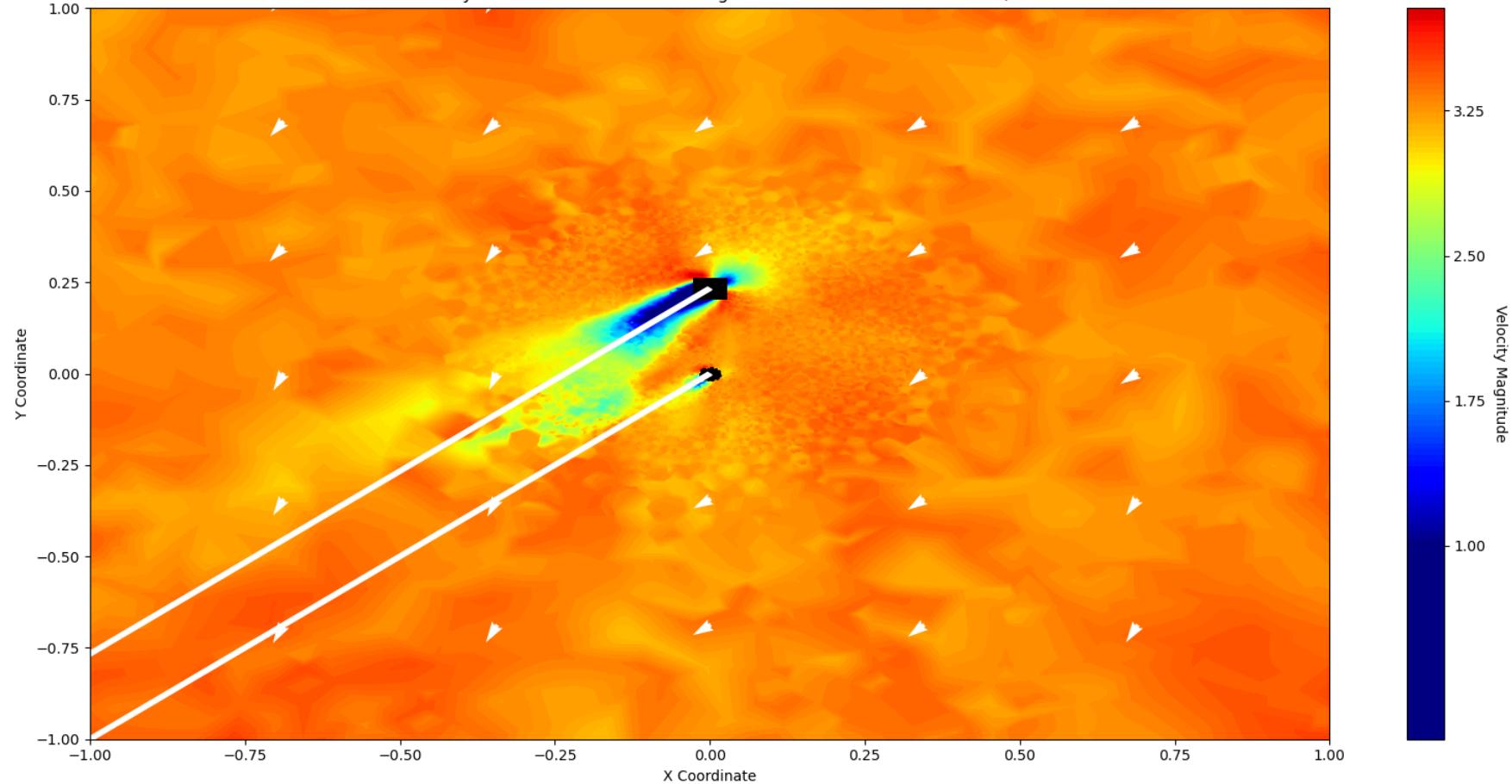
Total Velocity in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



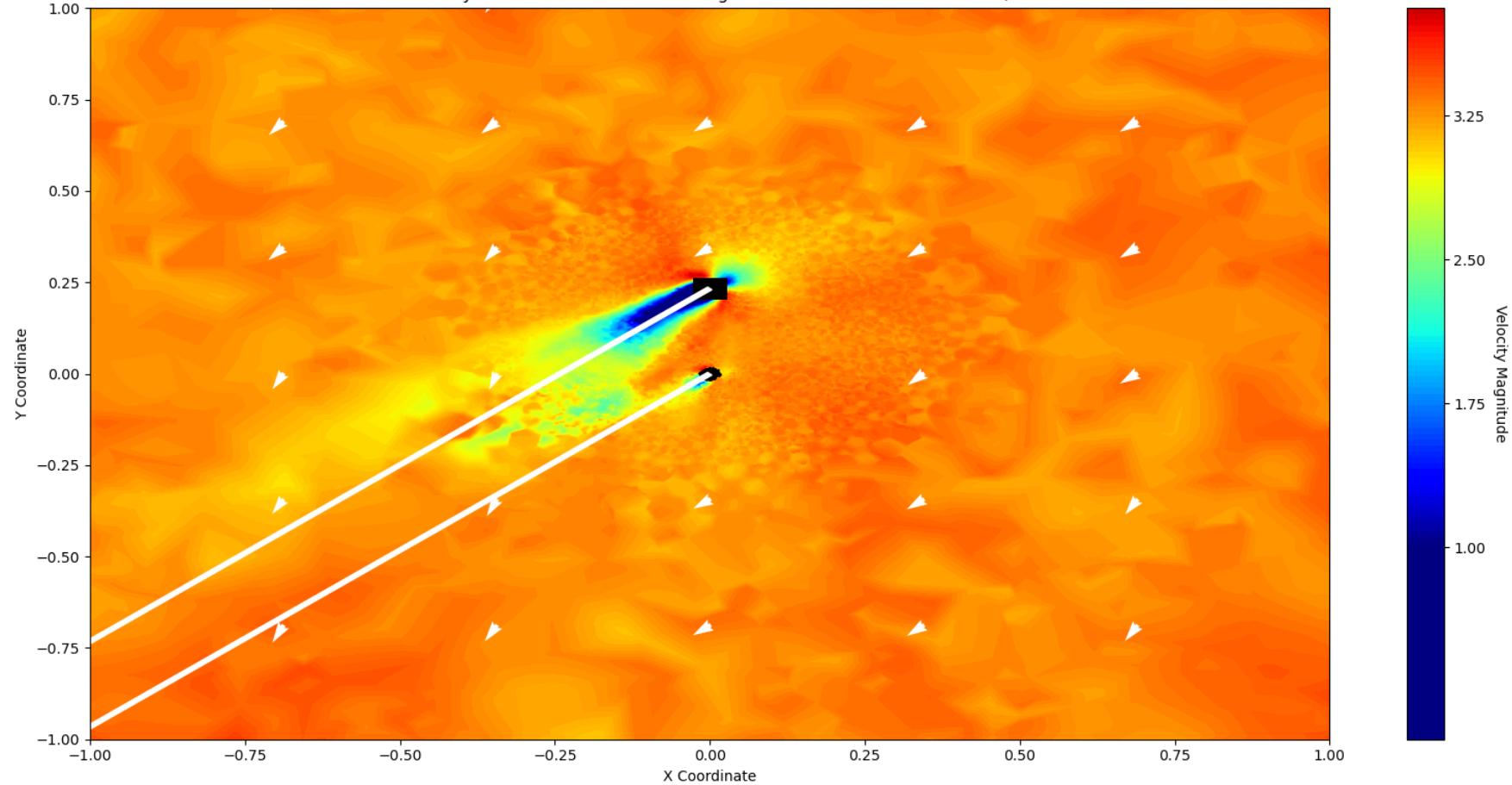
Total Velocity in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



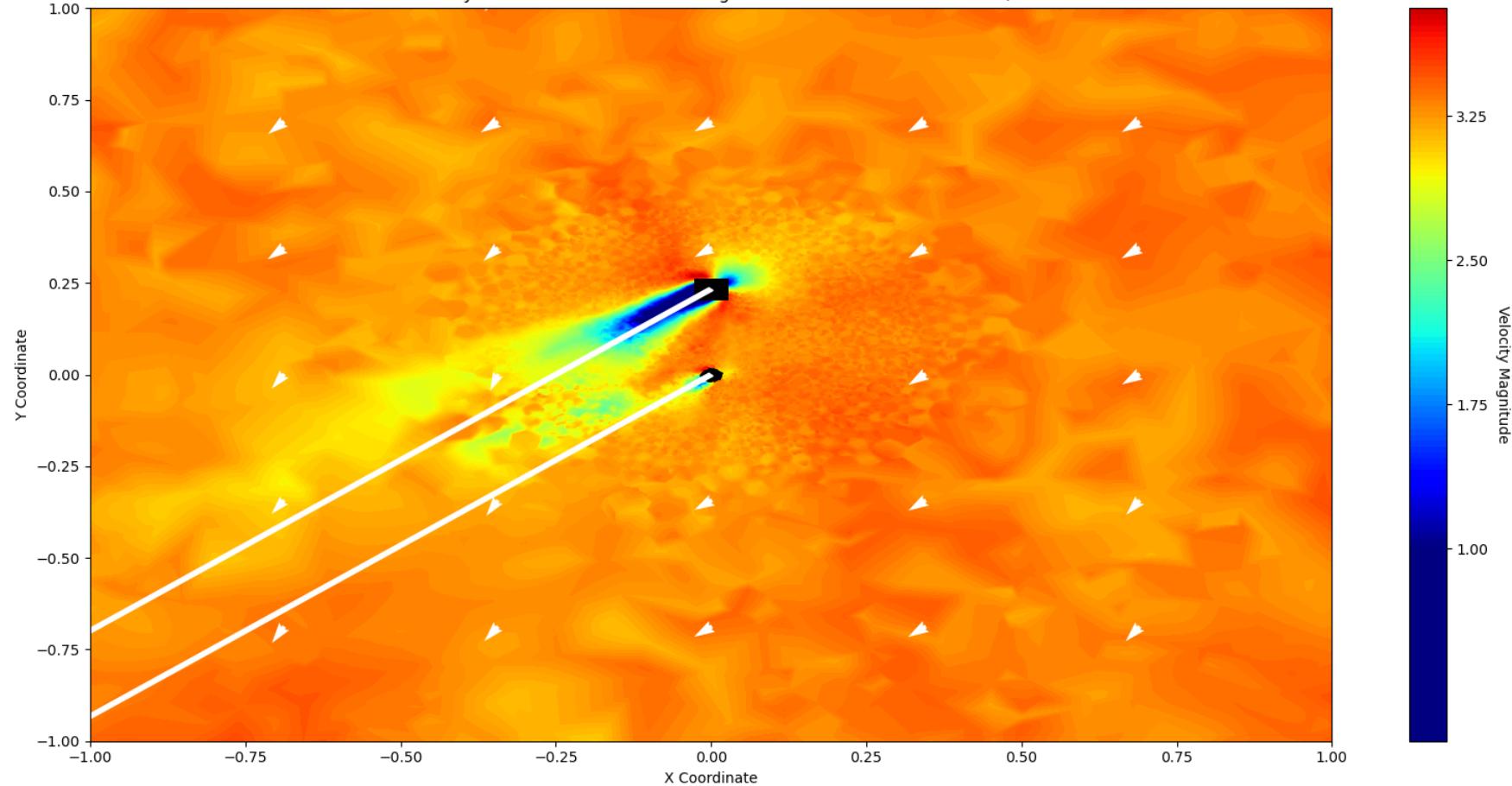
Total Velocity in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



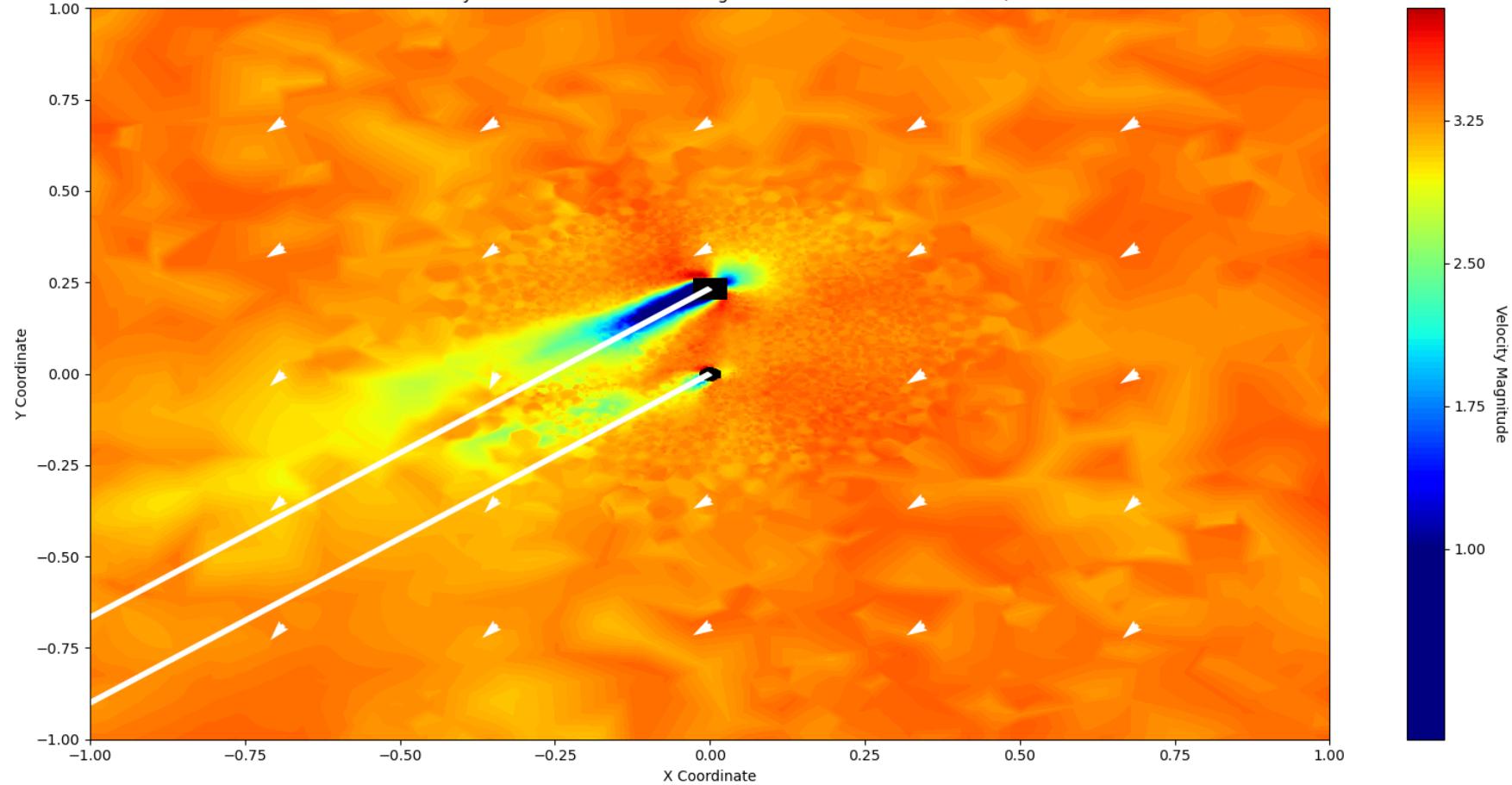
Total Velocity in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



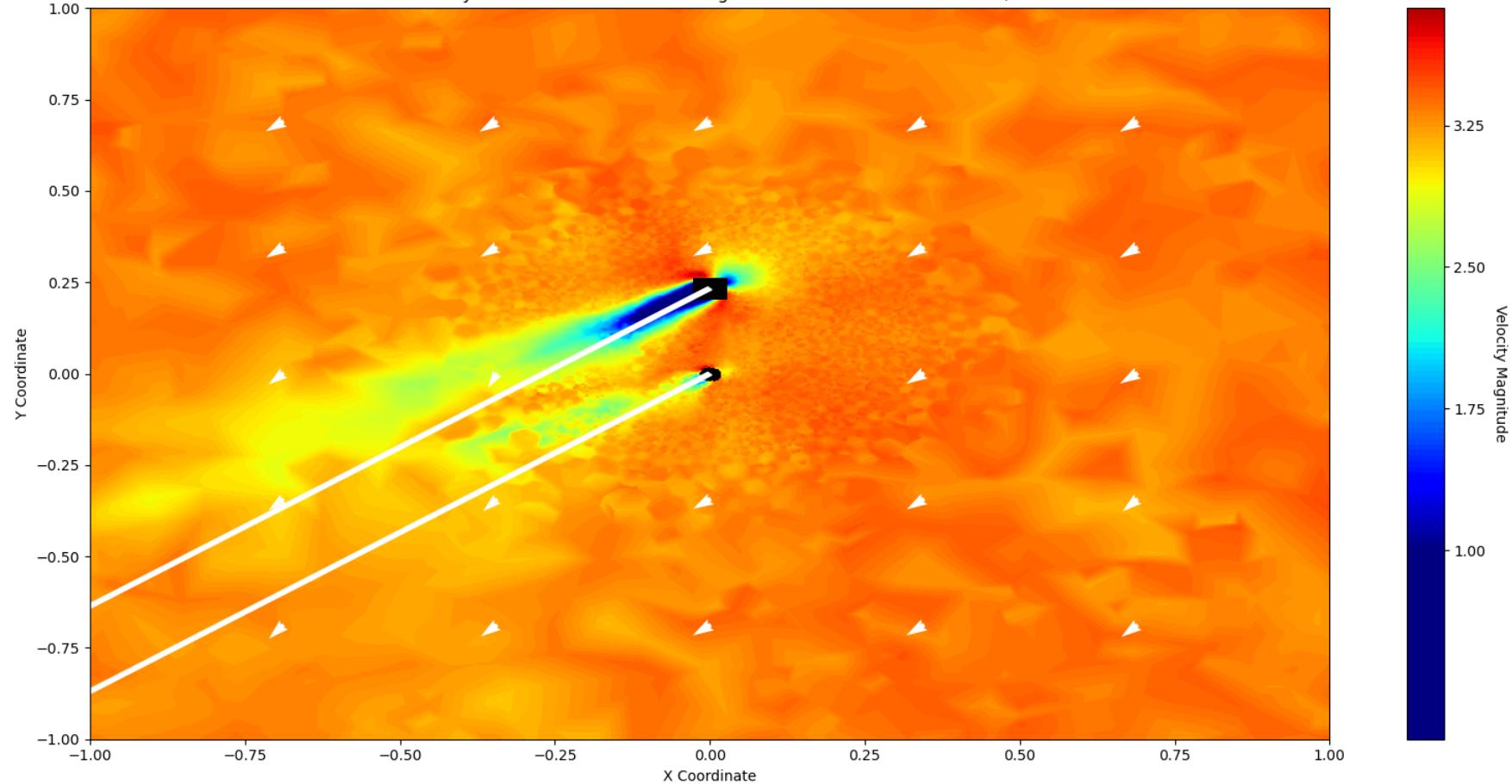
Total Velocity in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



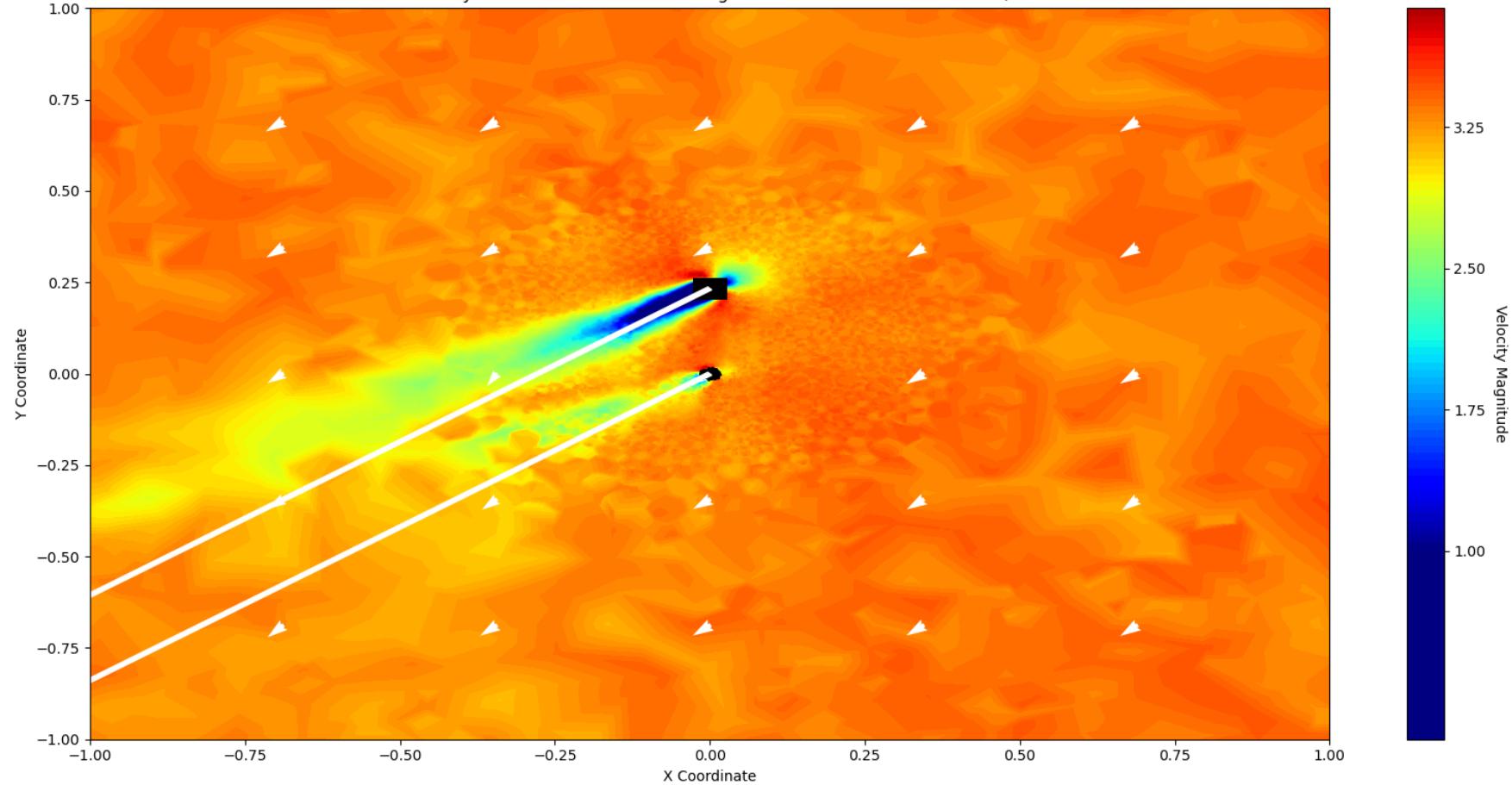
Total Velocity in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



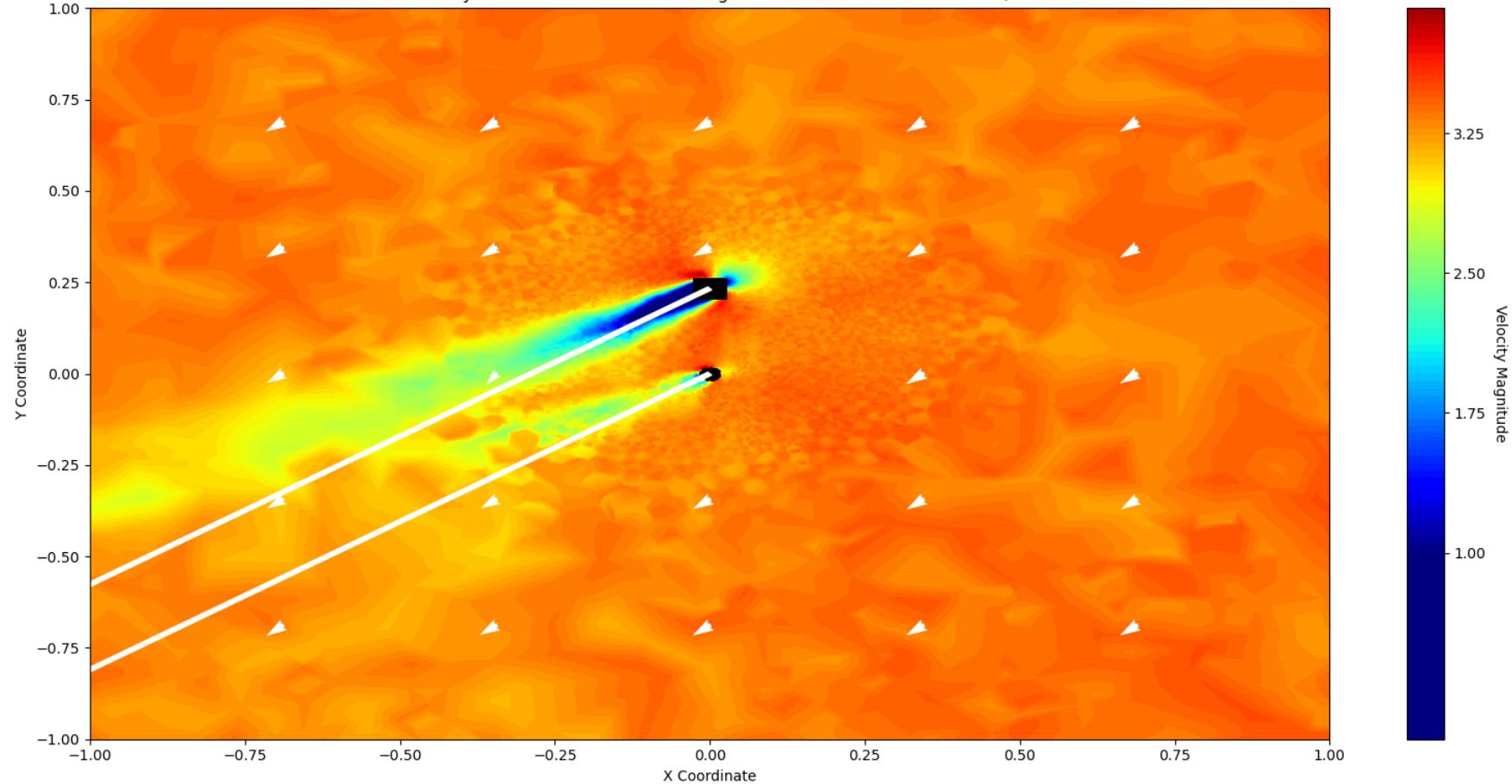
Total Velocity in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



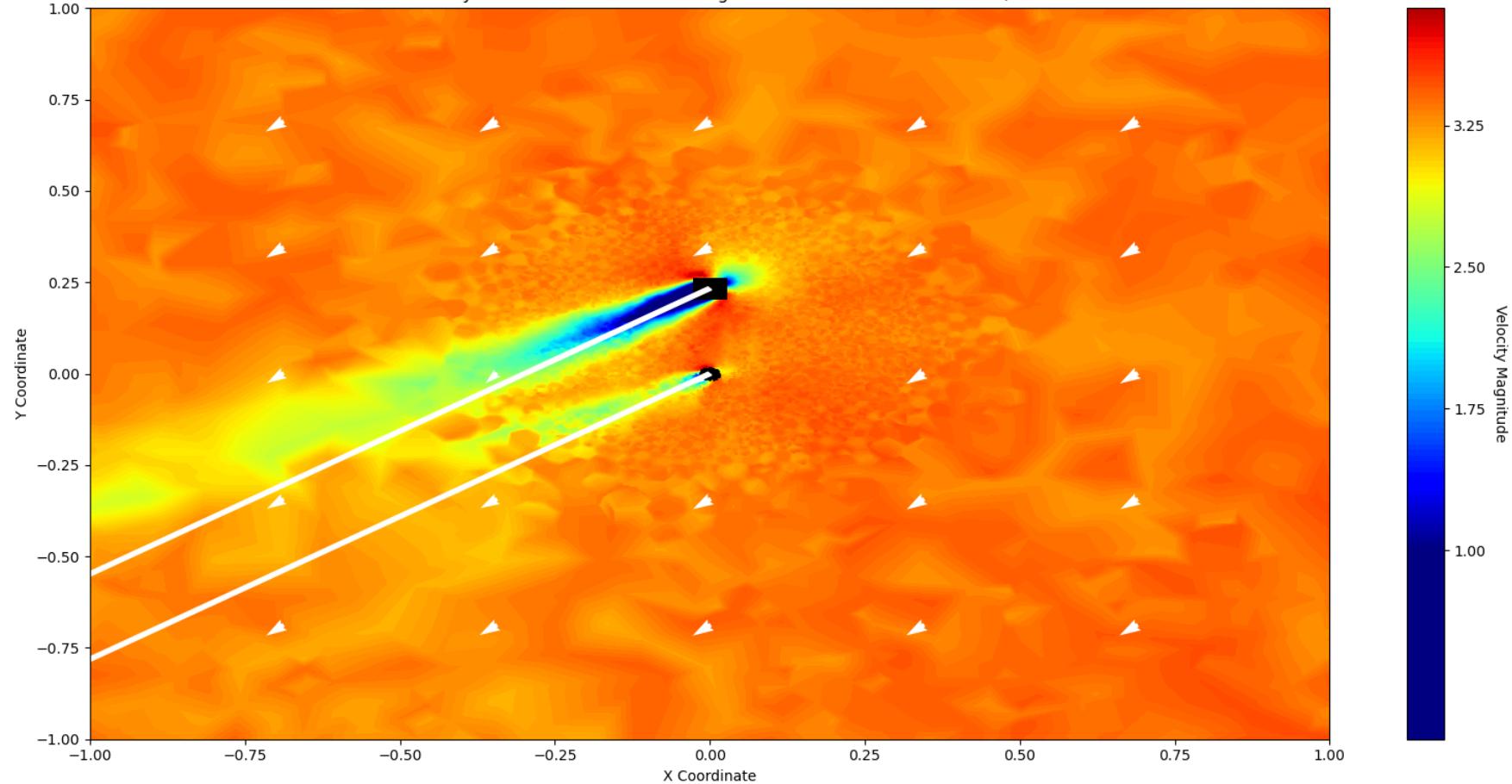
Total Velocity in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



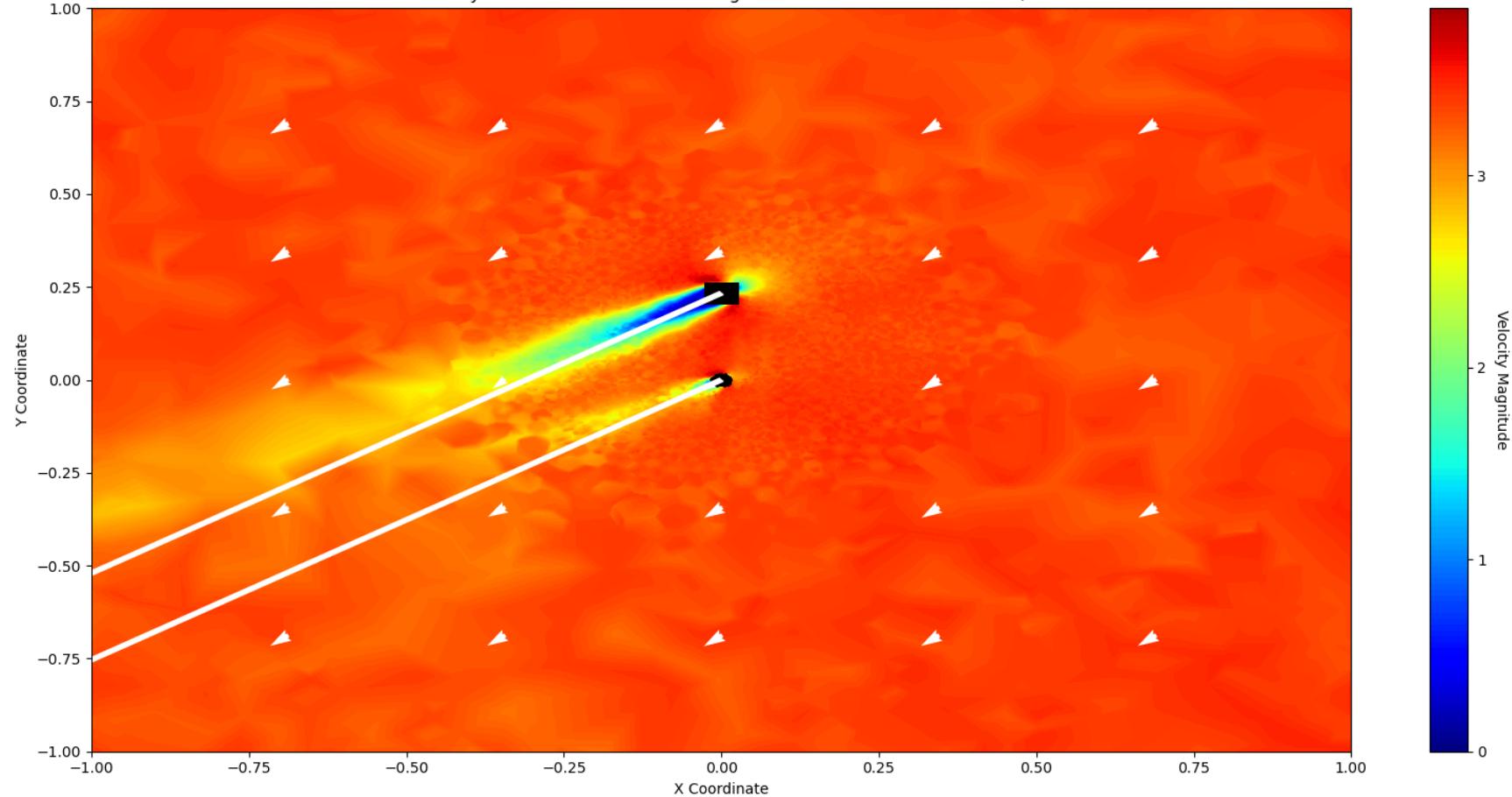
Total Velocity in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



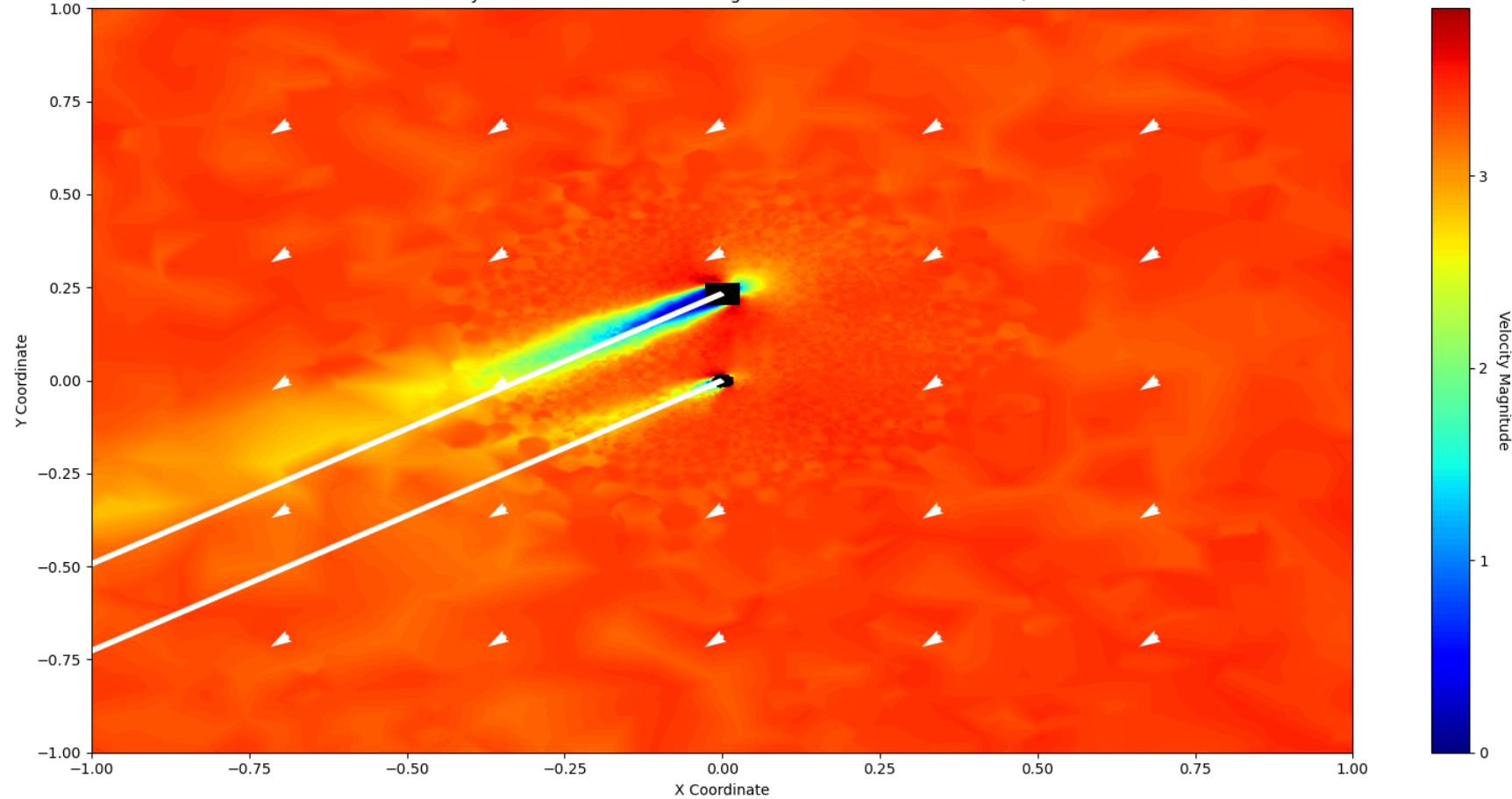
Total Velocity in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



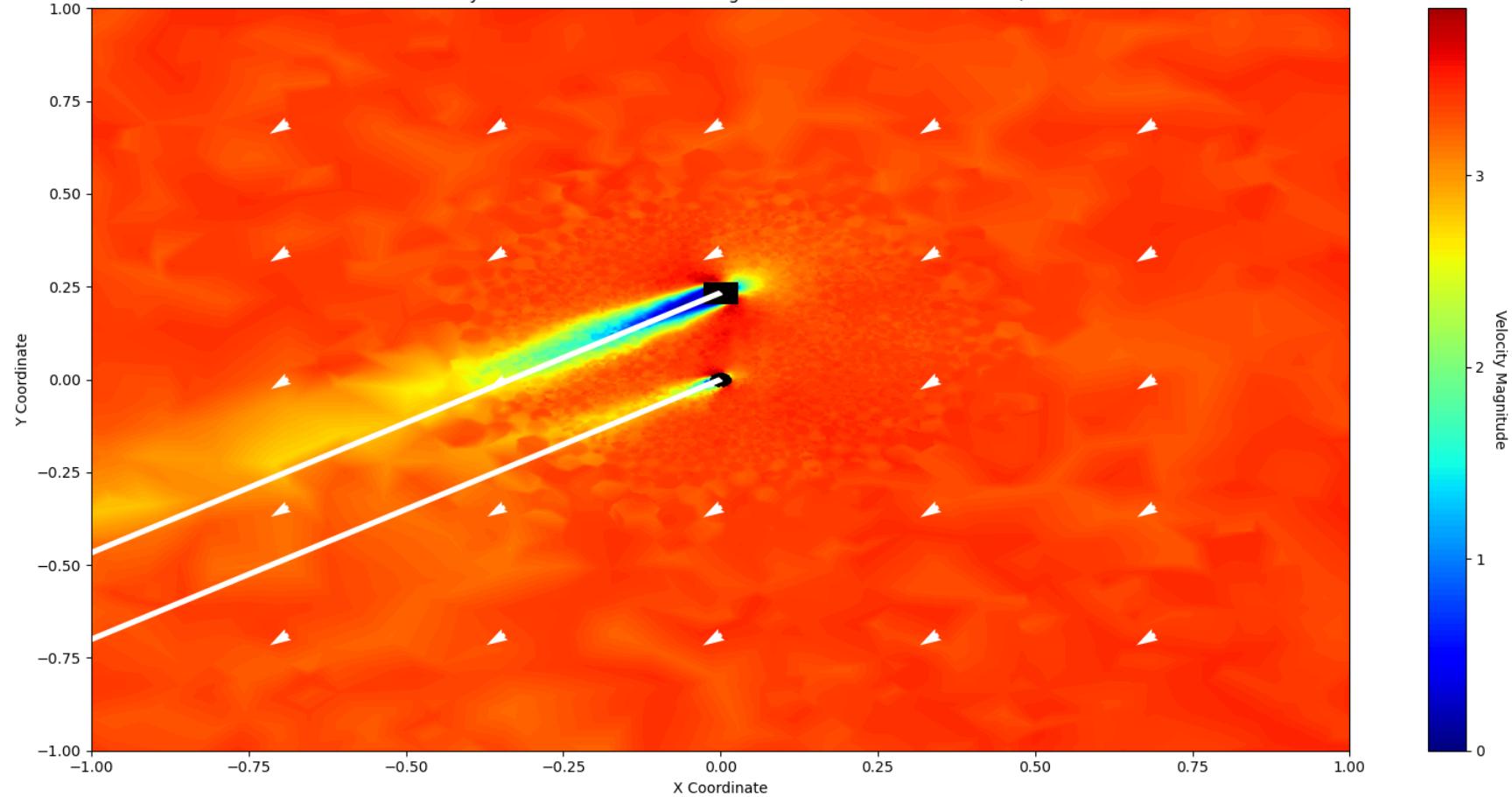
Total Velocity in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



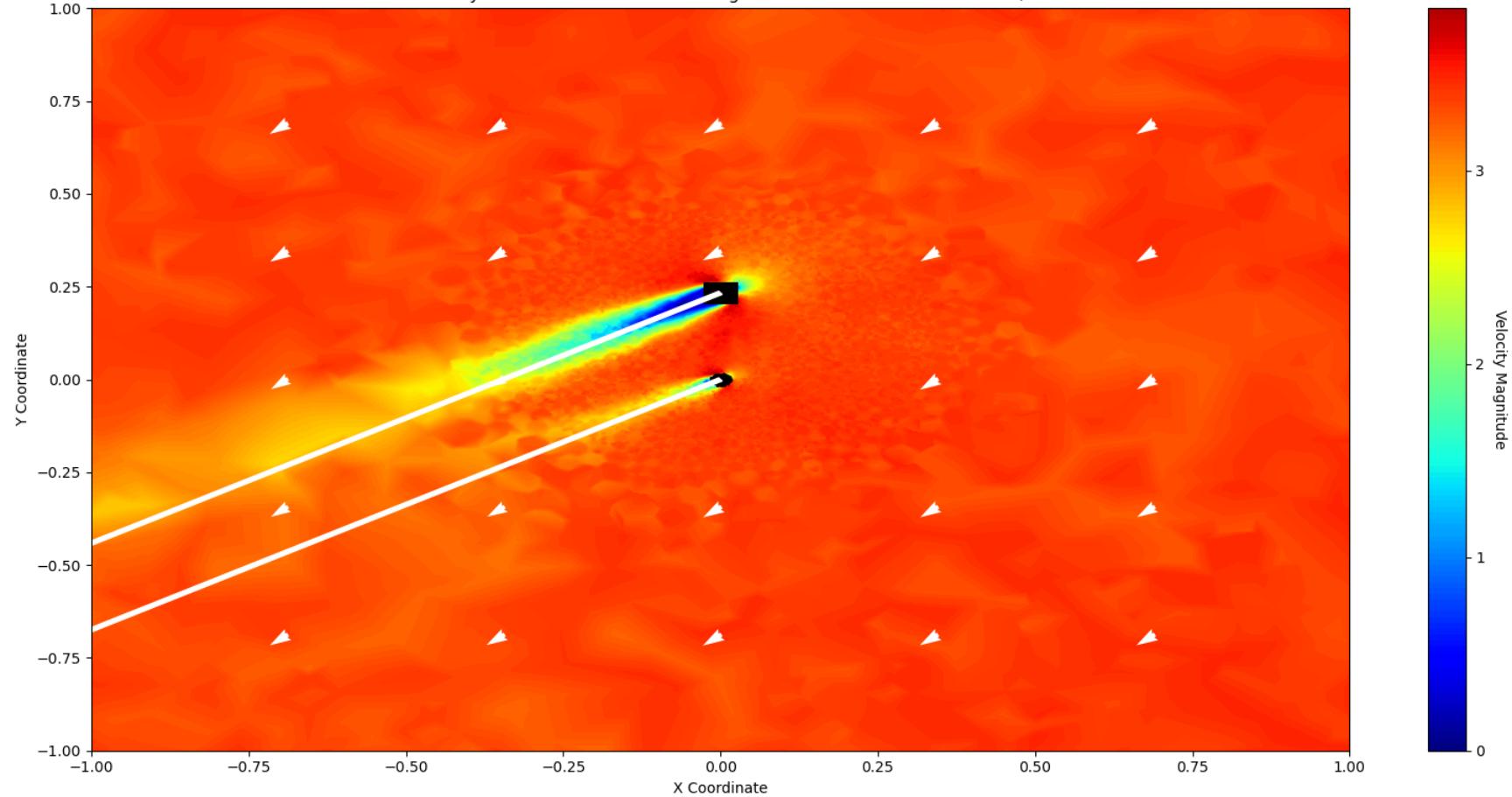
Total Velocity in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



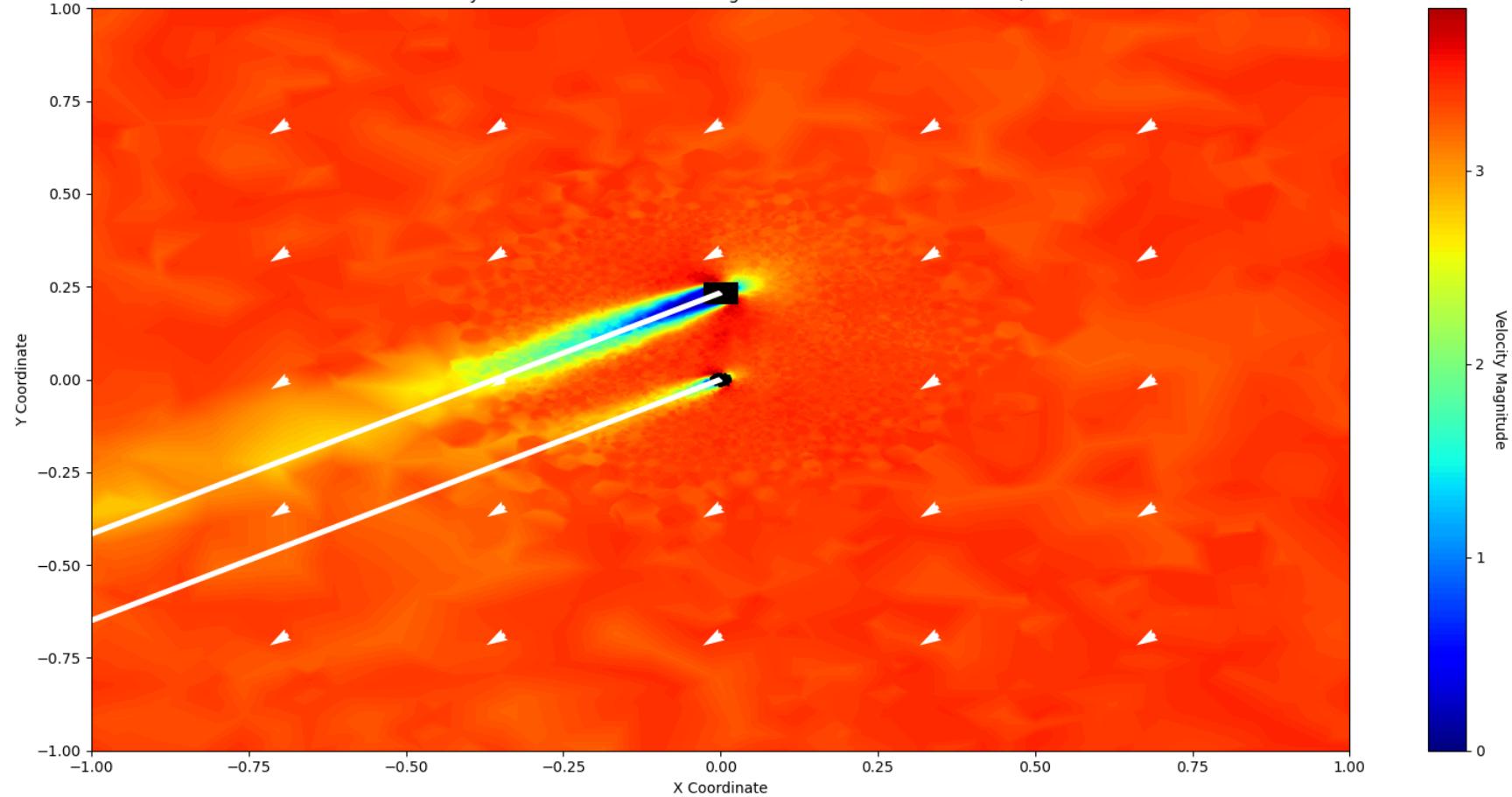
Total Velocity in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



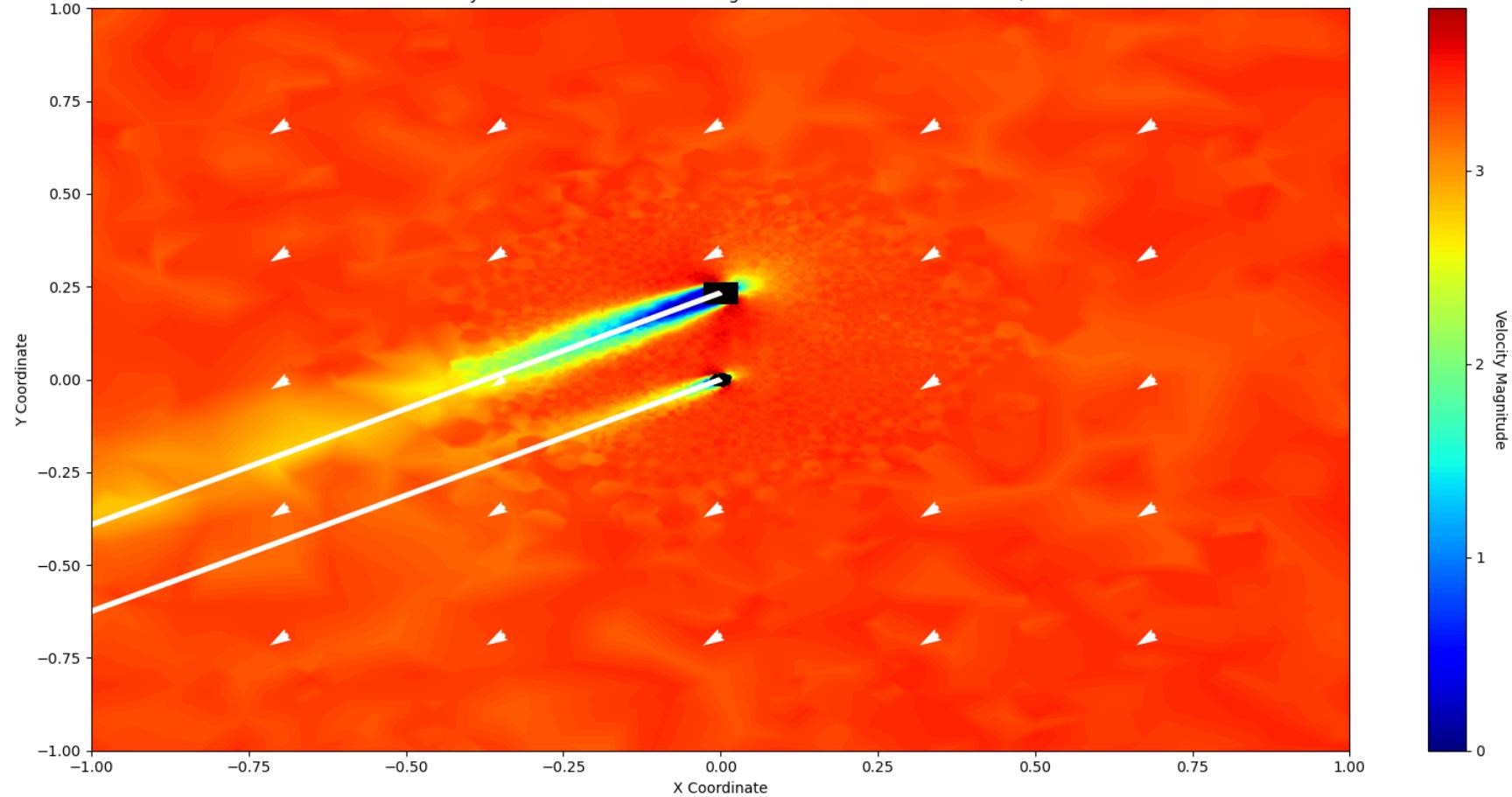
Total Velocity in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



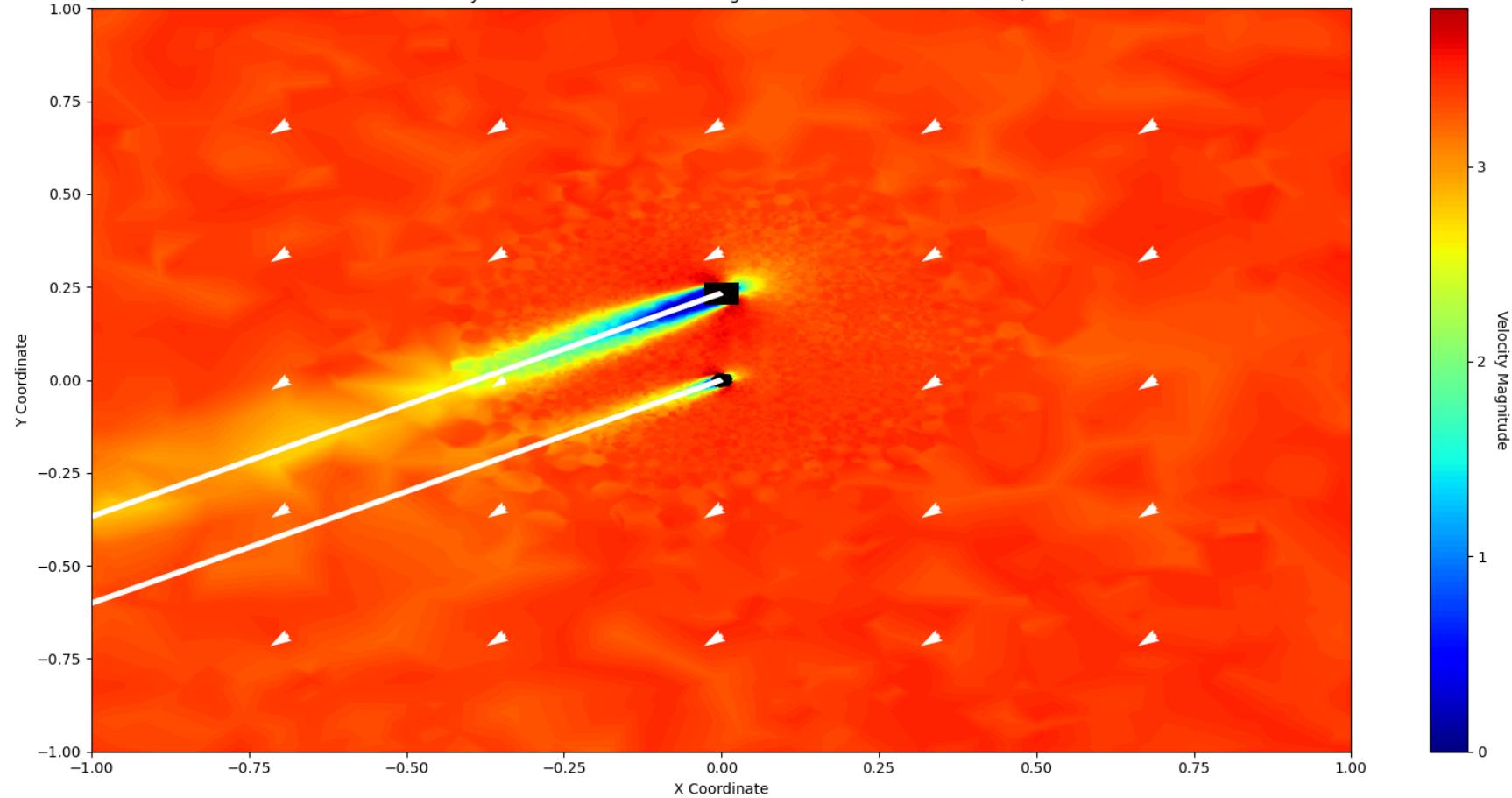
Total Velocity in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



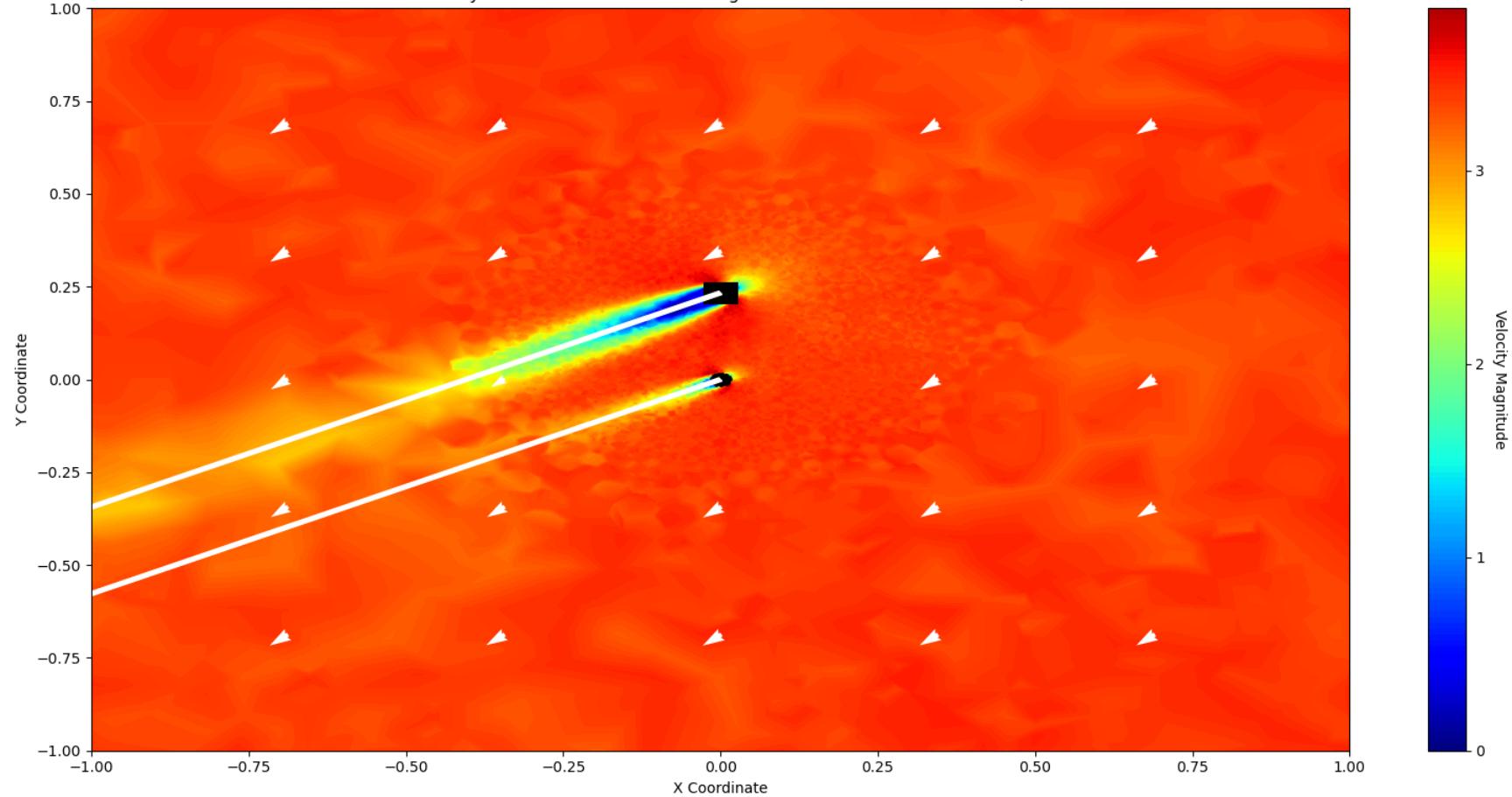
Total Velocity in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



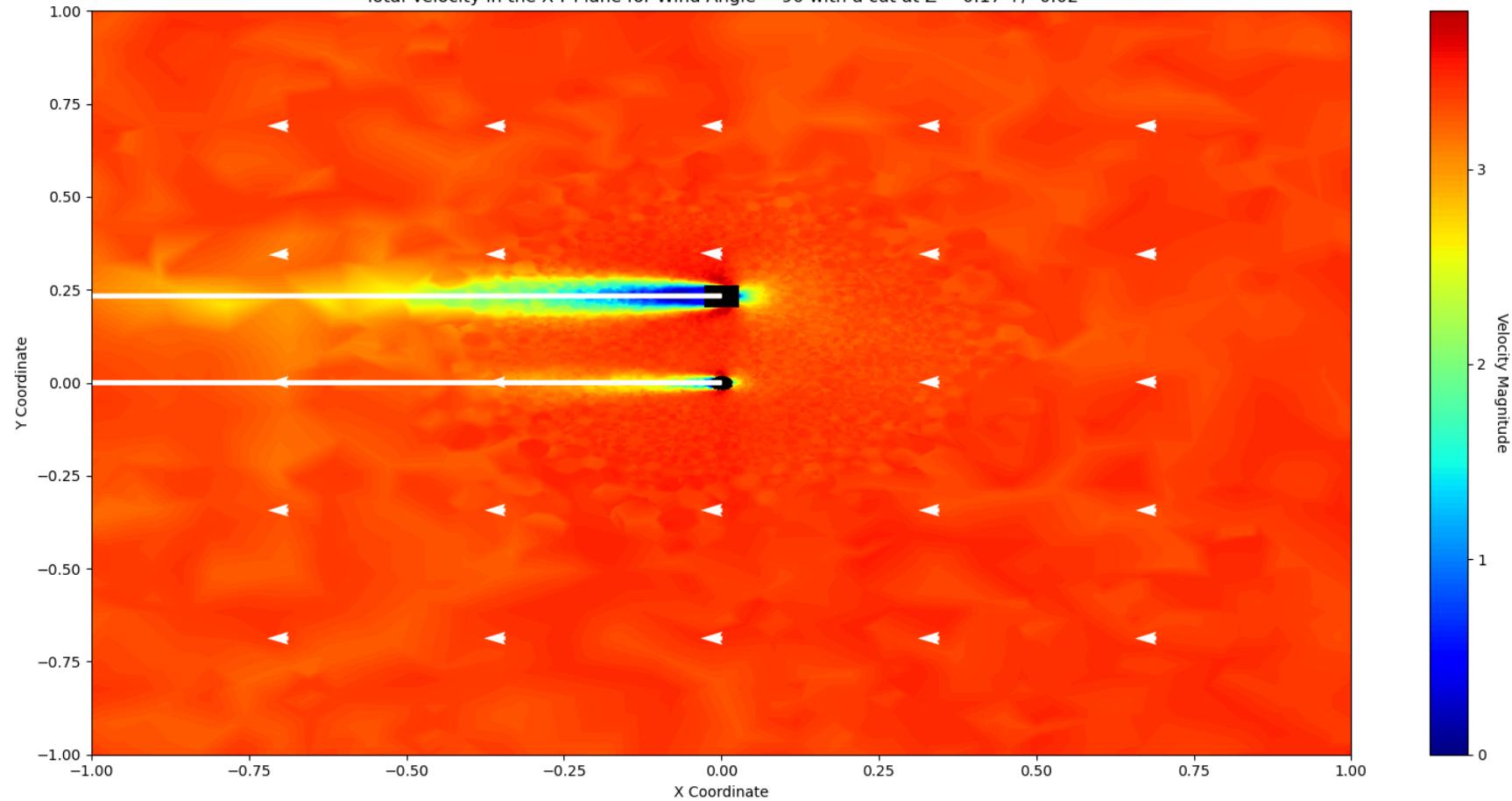
Total Velocity in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



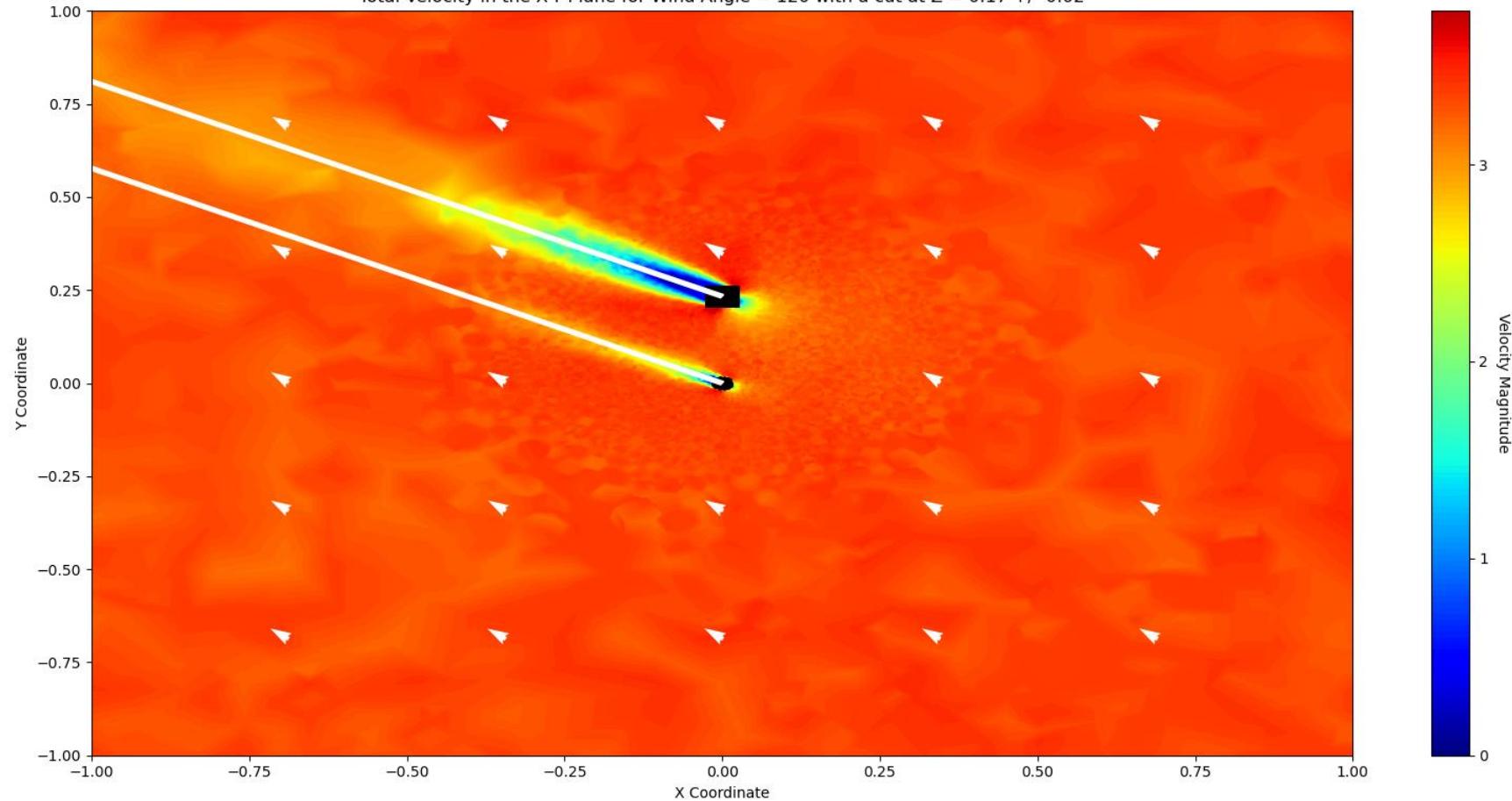
Total Velocity in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



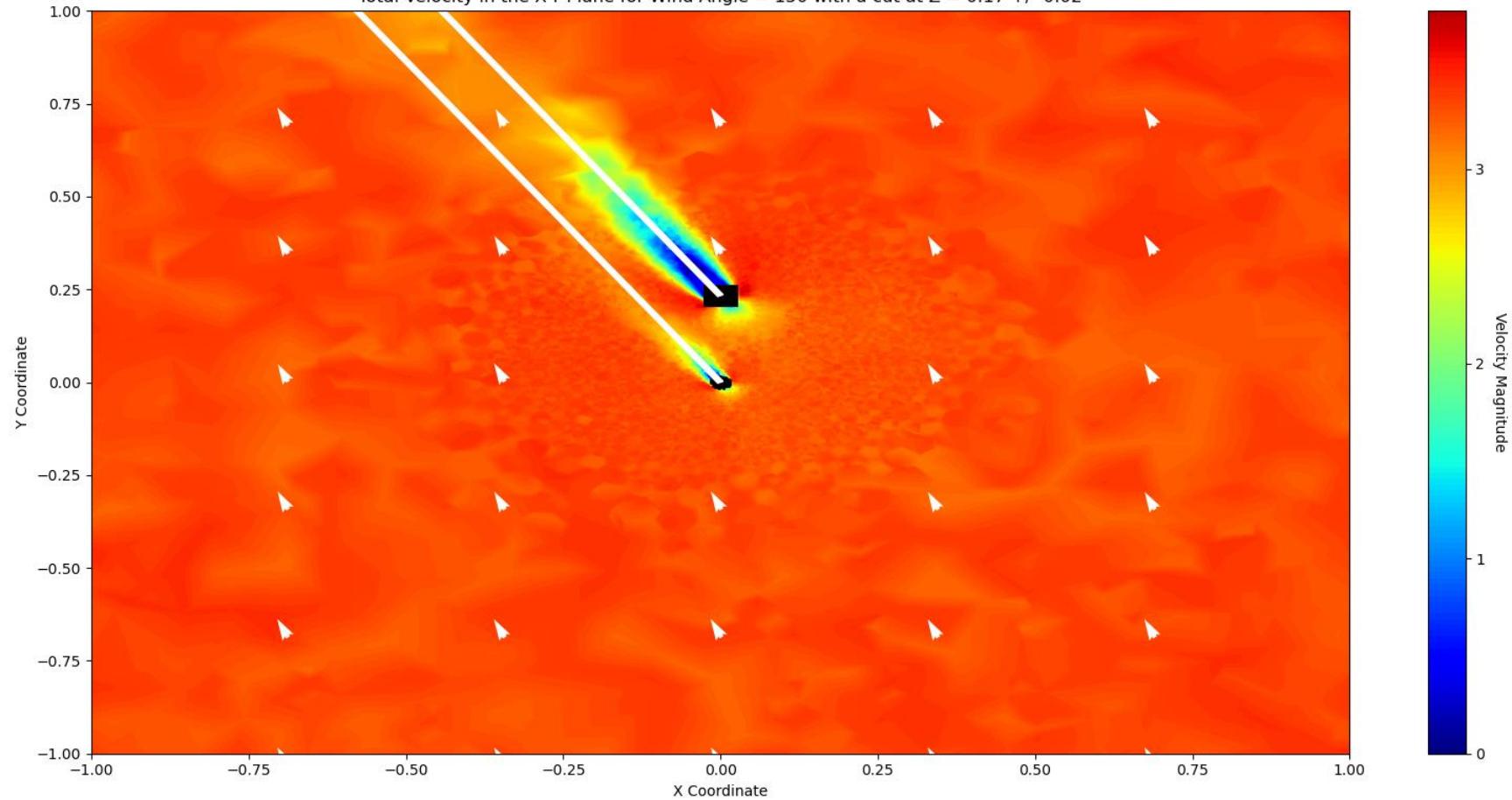
Total Velocity in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



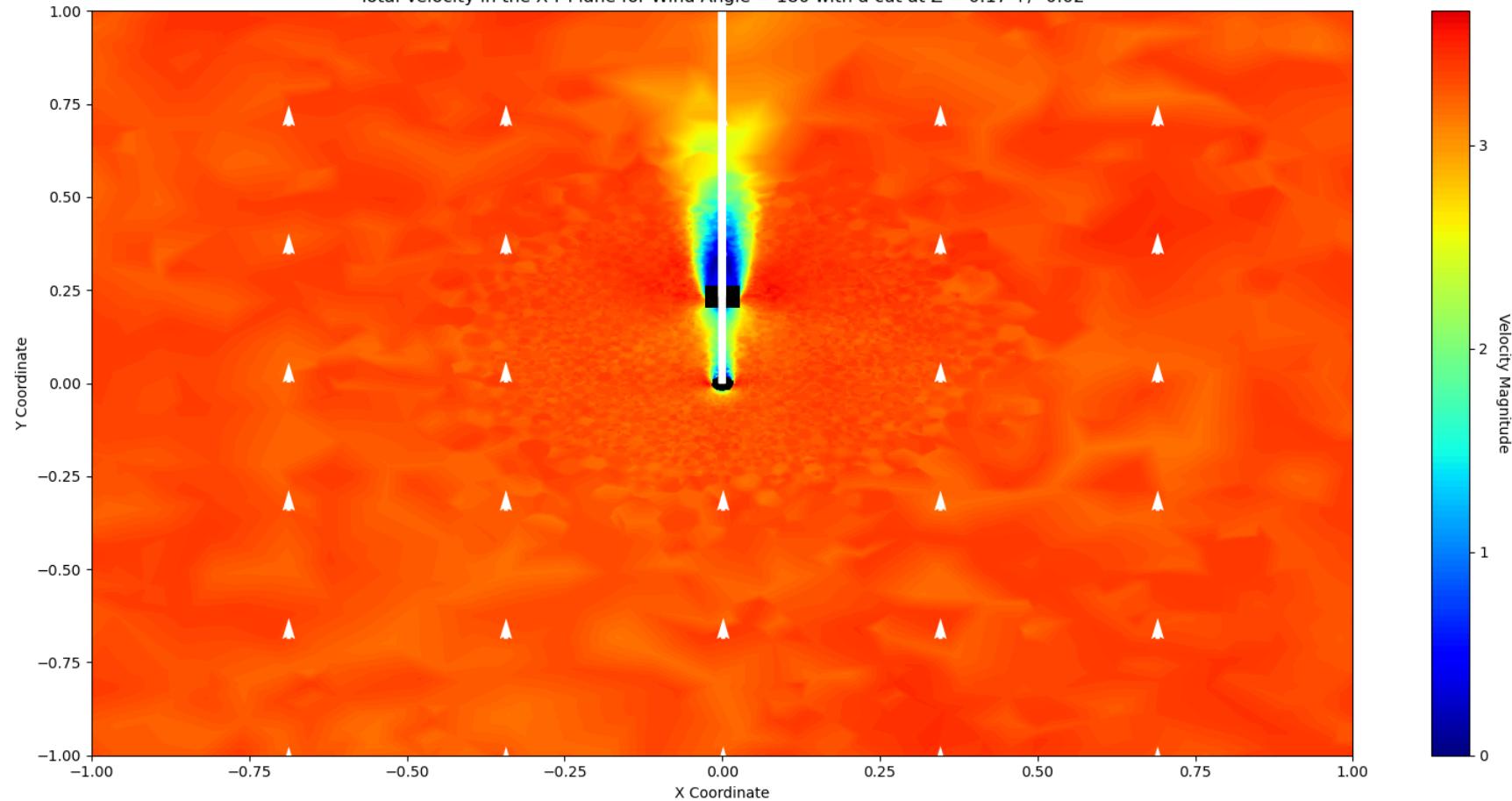
Total Velocity in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



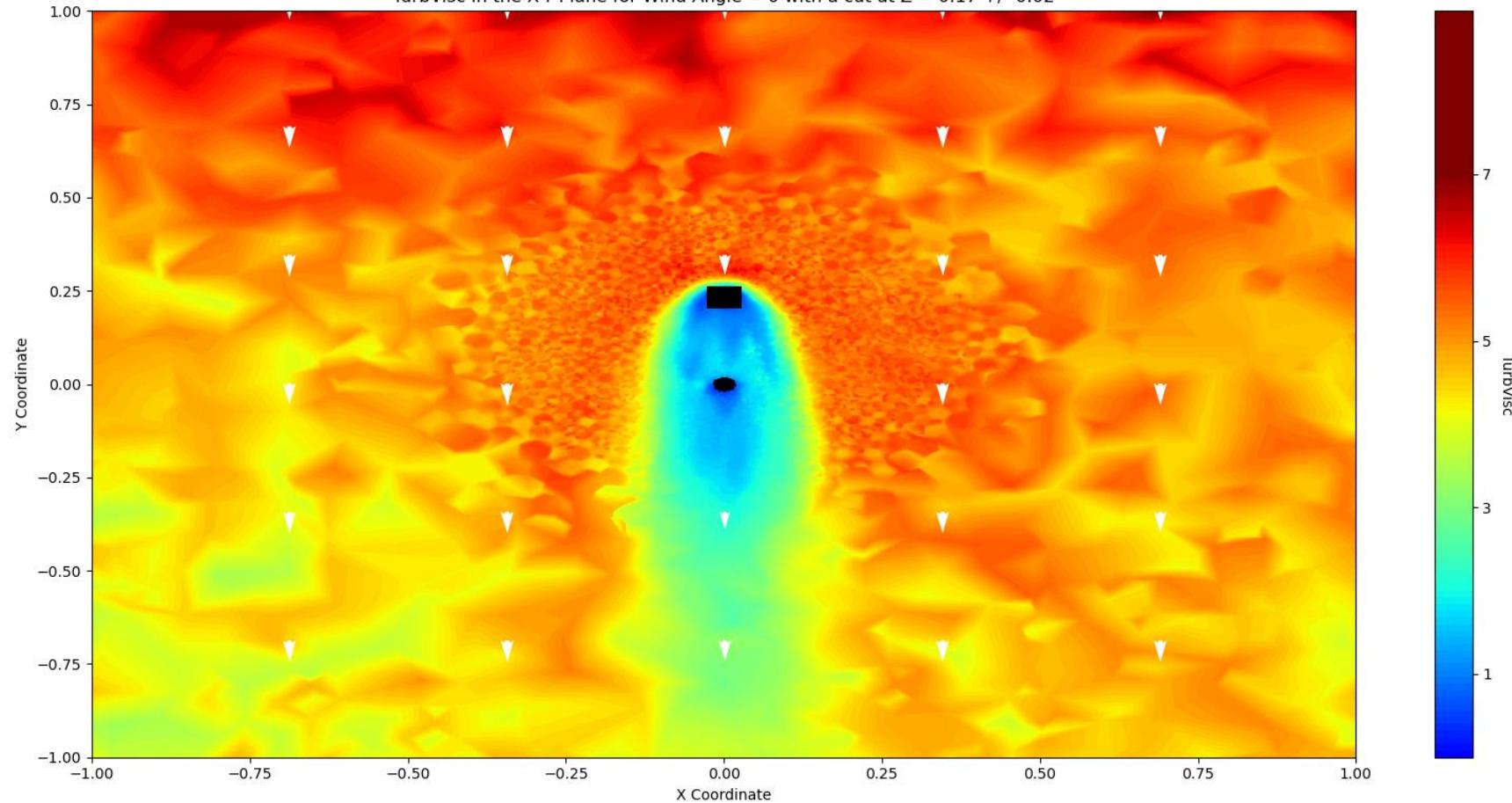
Total Velocity in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



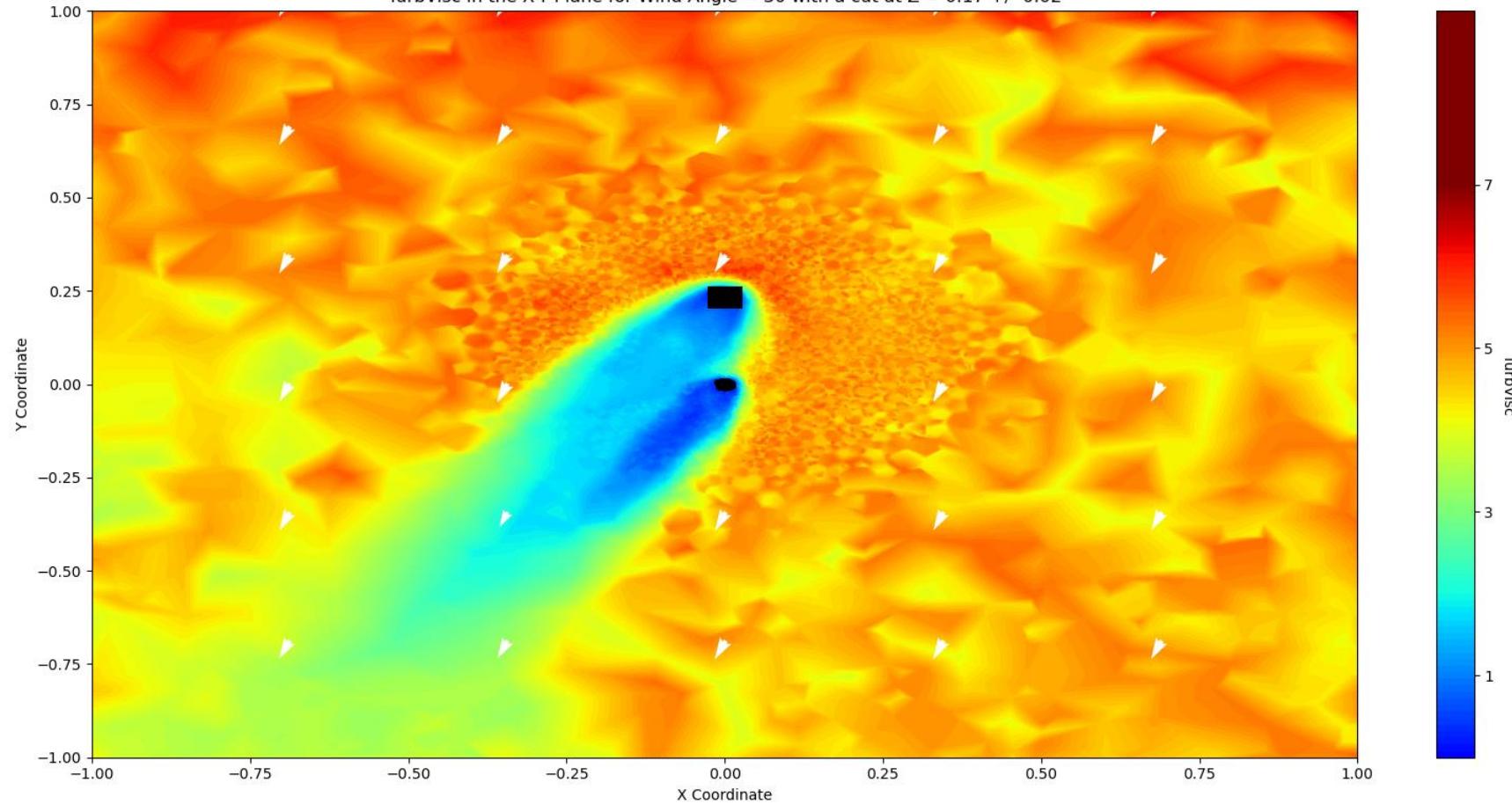
Total Velocity in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



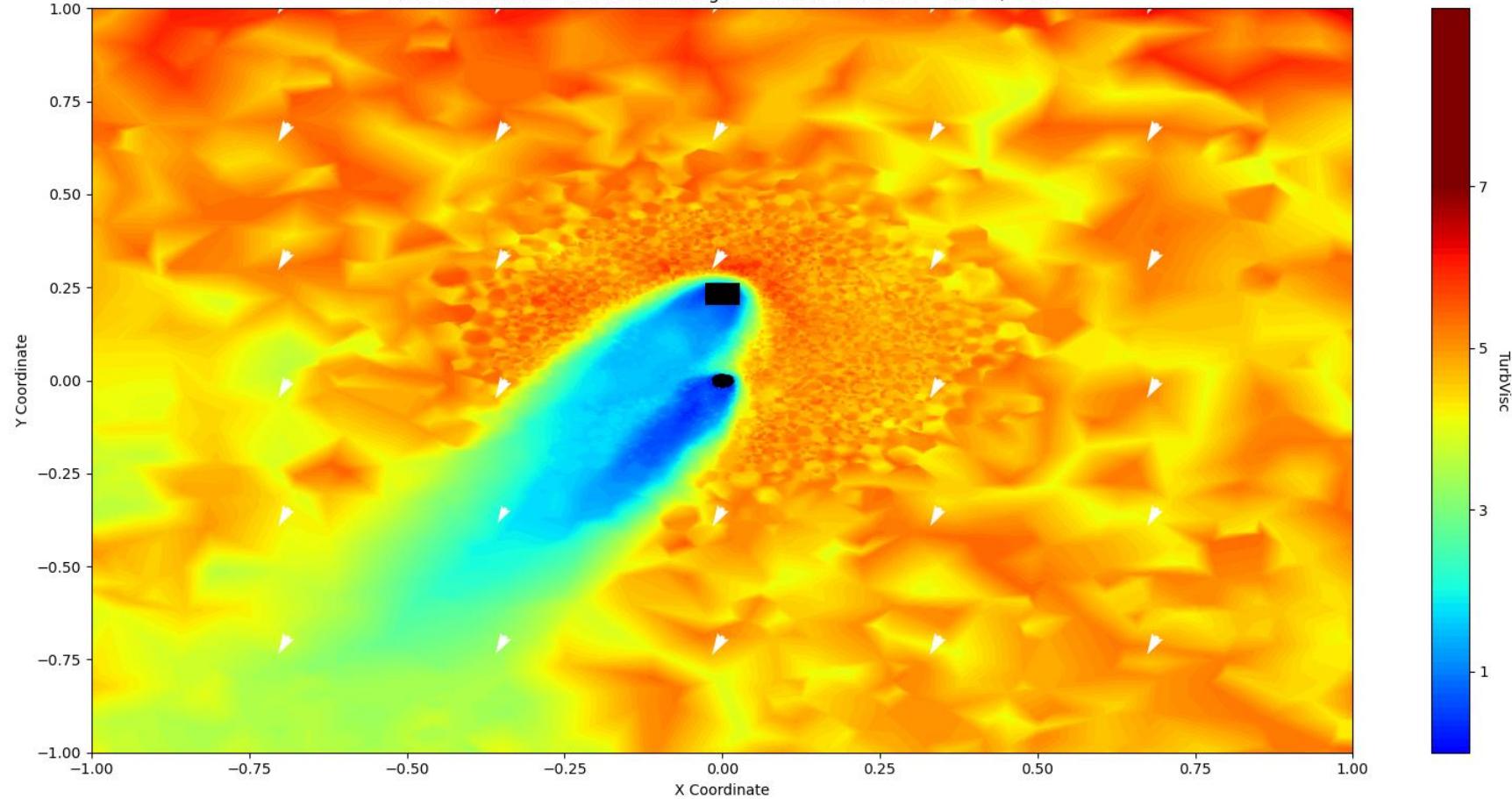
TurbVisc in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



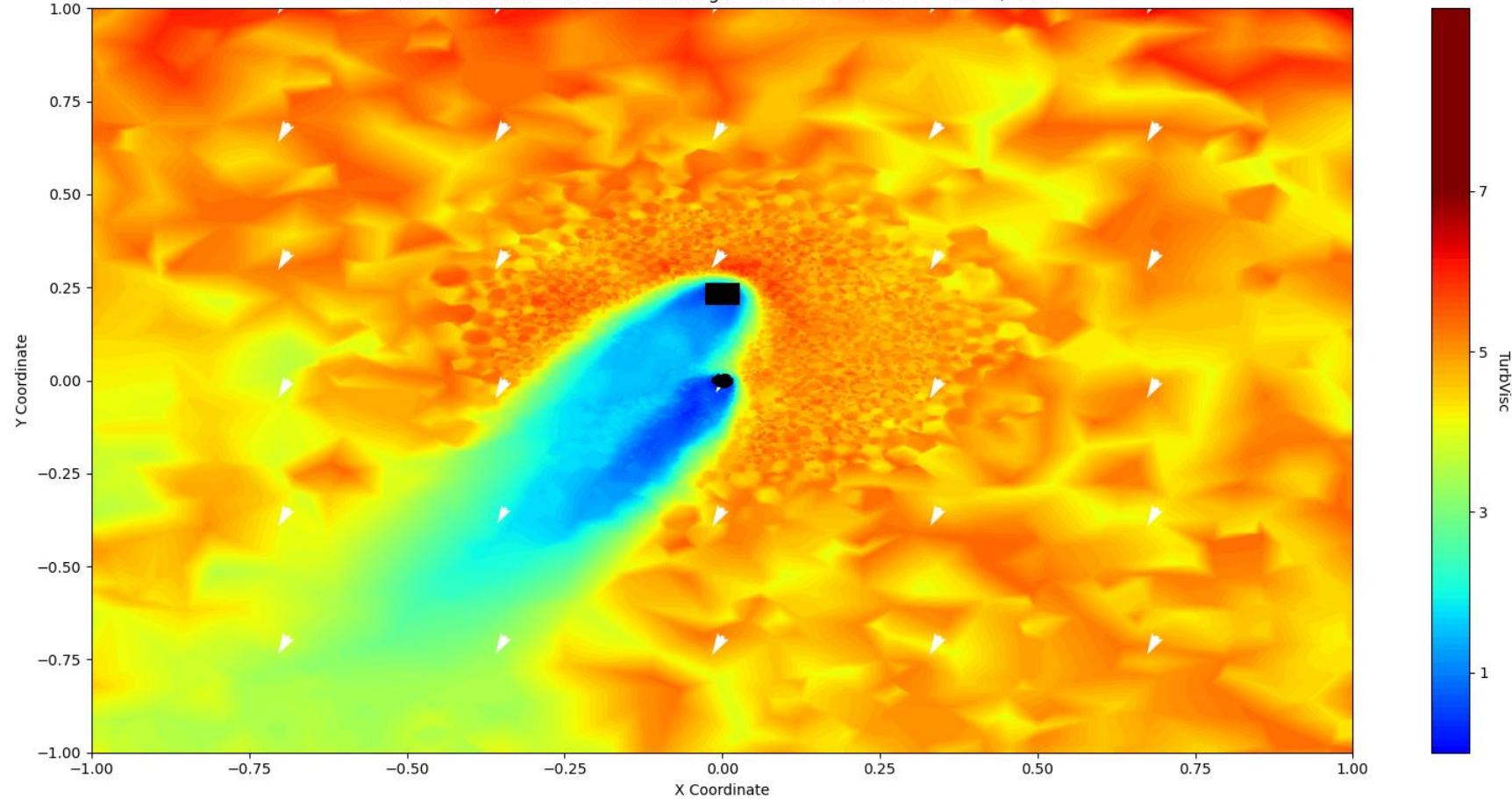
TurbVisc in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



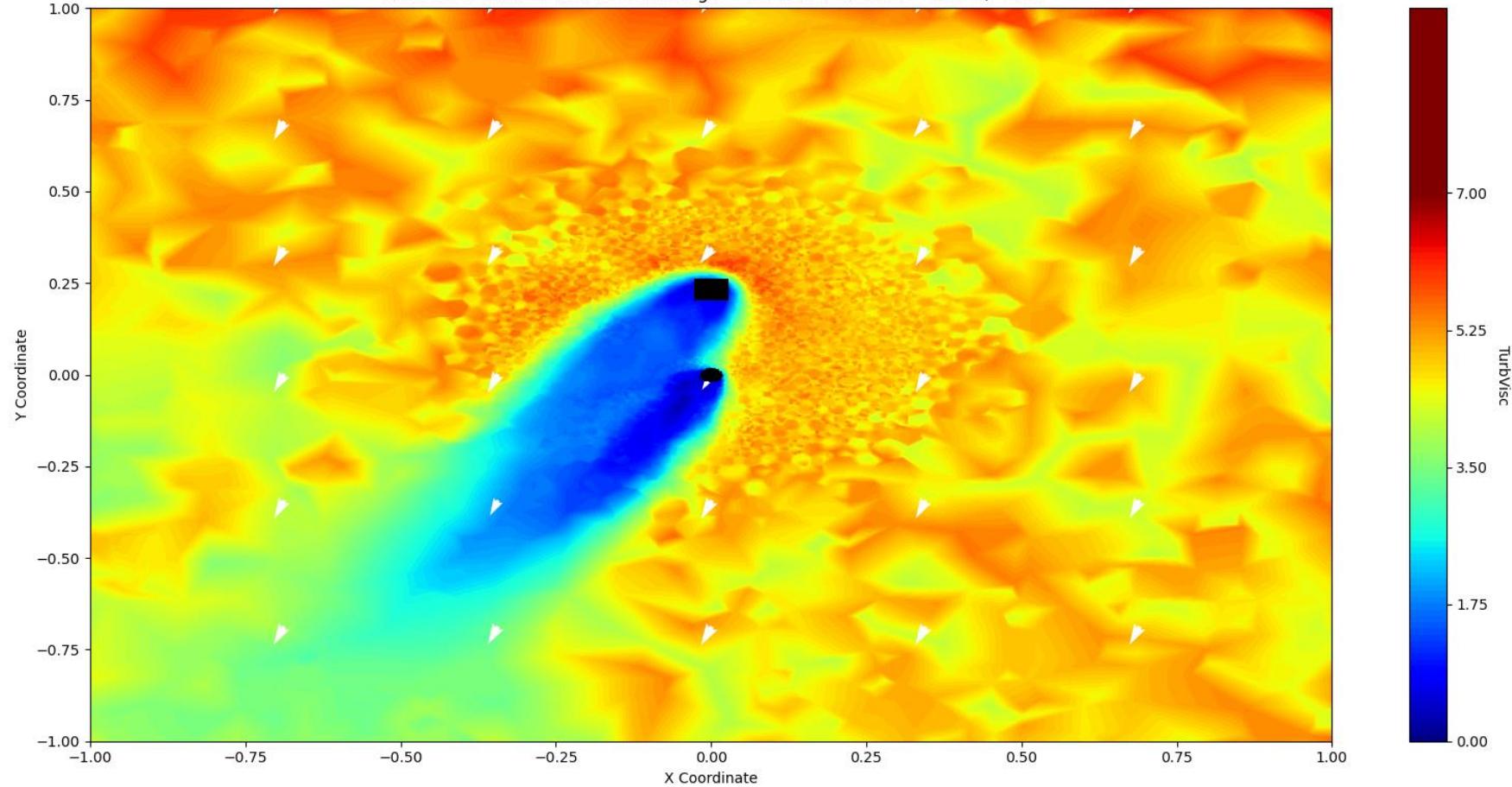
TurbVisc in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



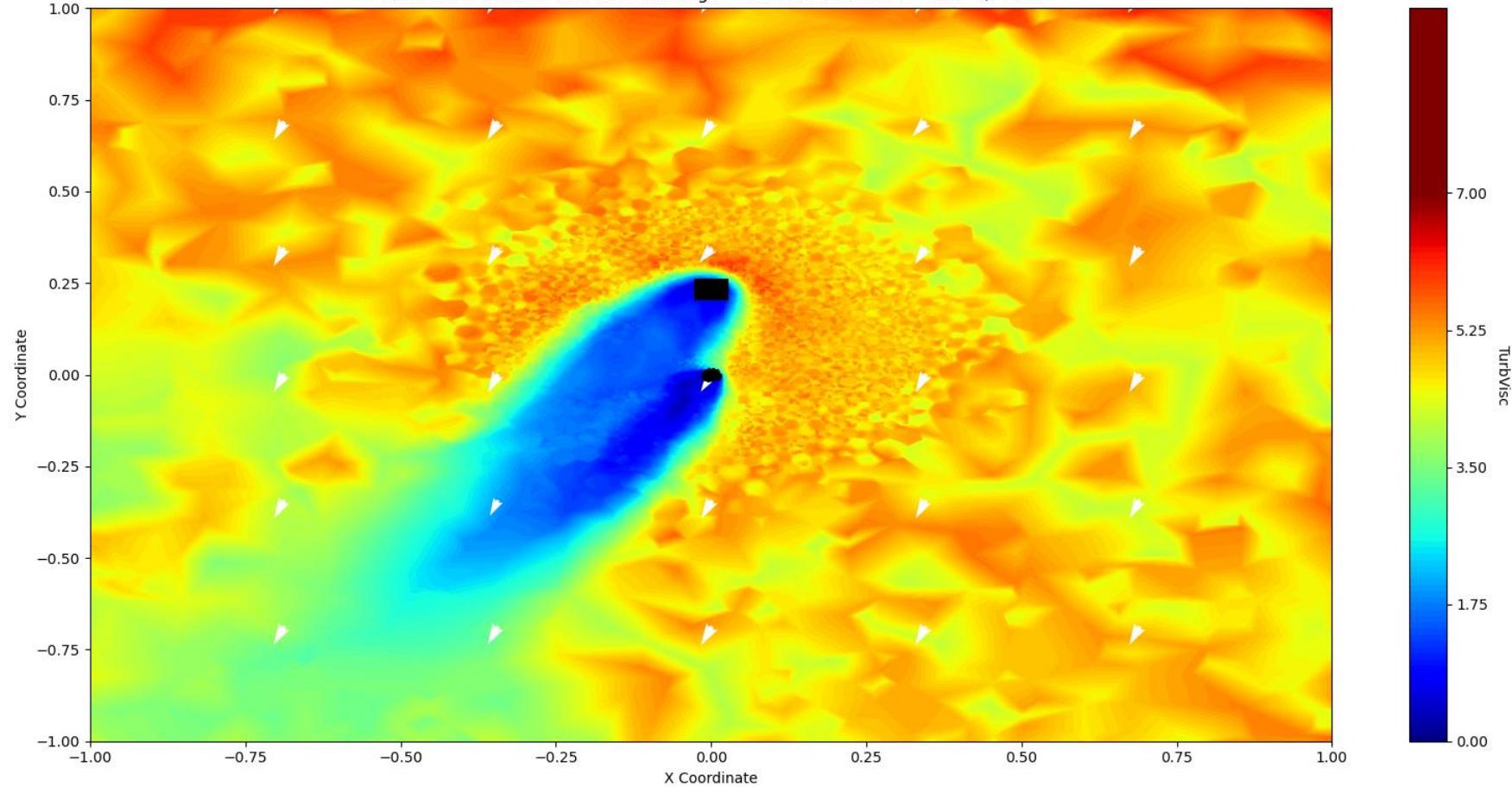
TurbVisc in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



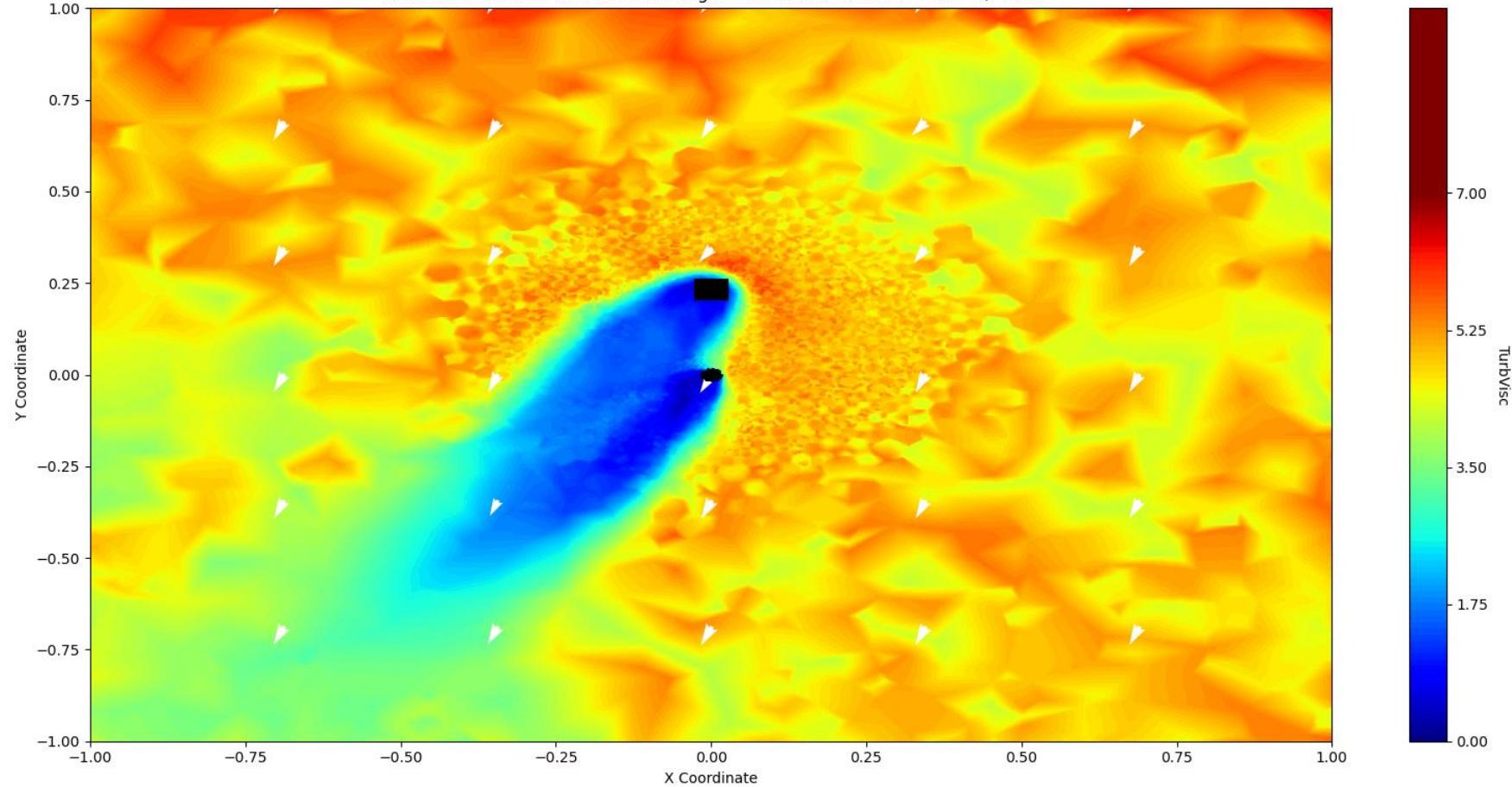
TurbVisc in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



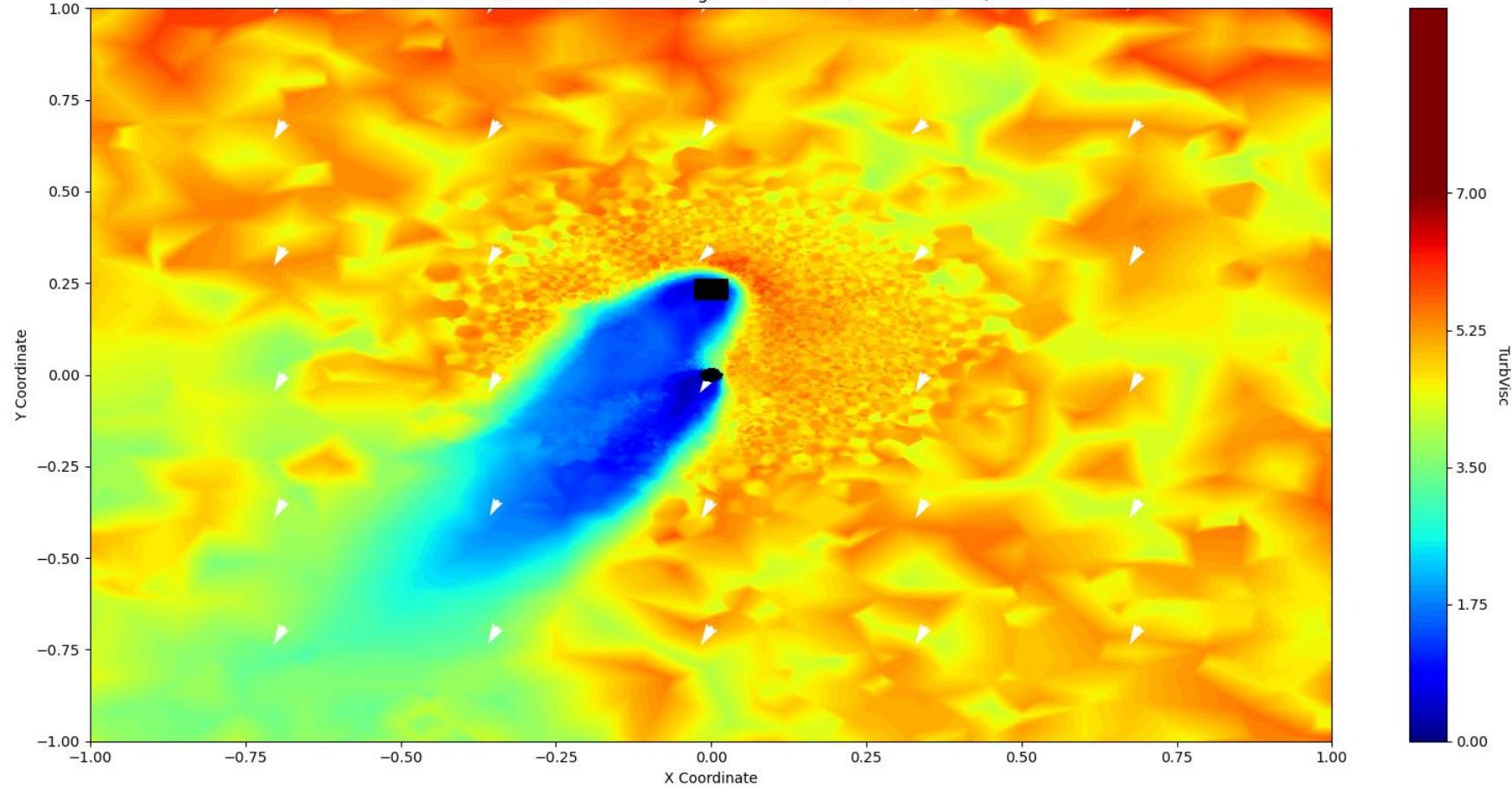
TurbVisc in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



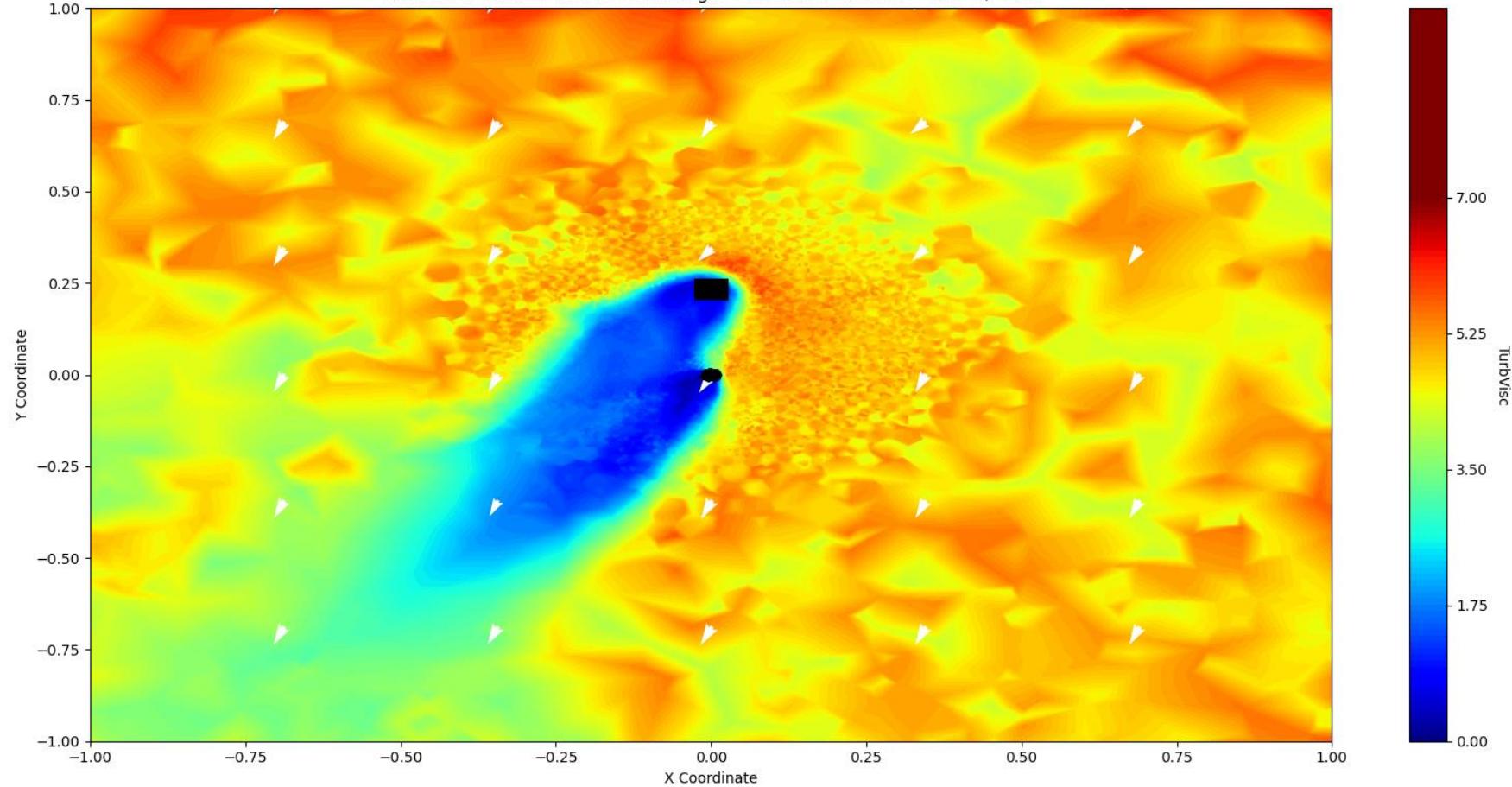
TurbVisc in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



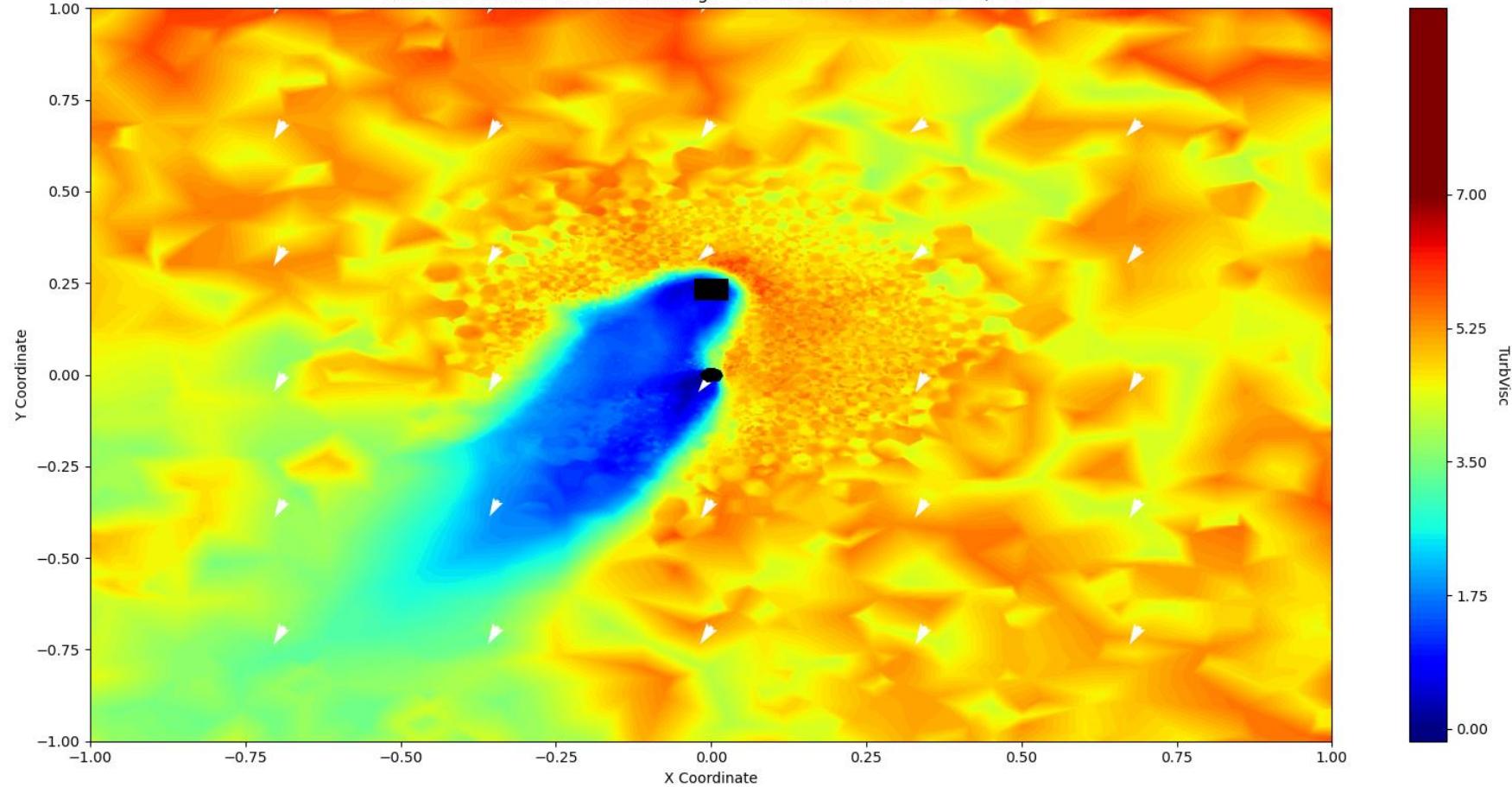
TurbVisc in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



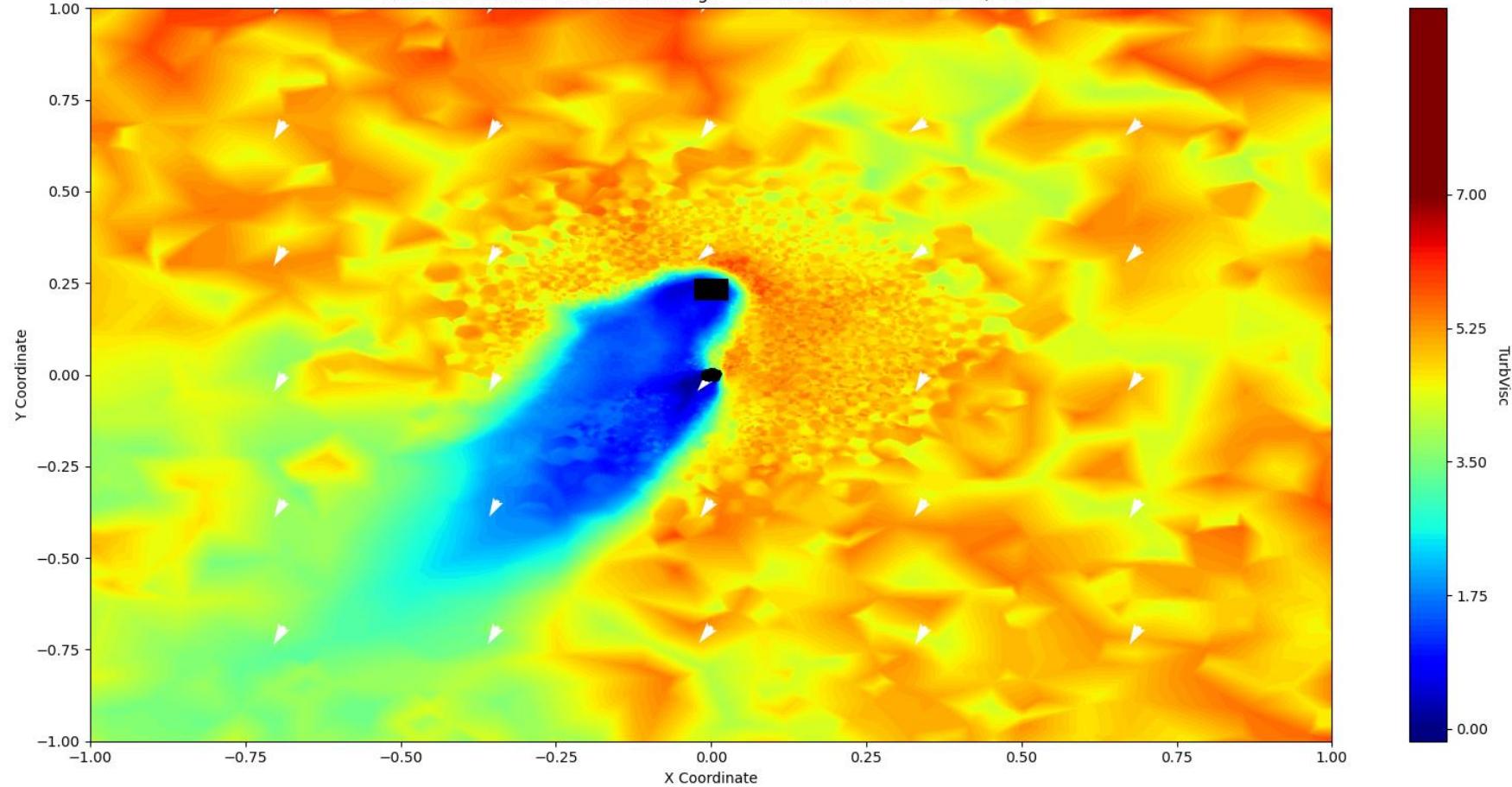
TurbVisc in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



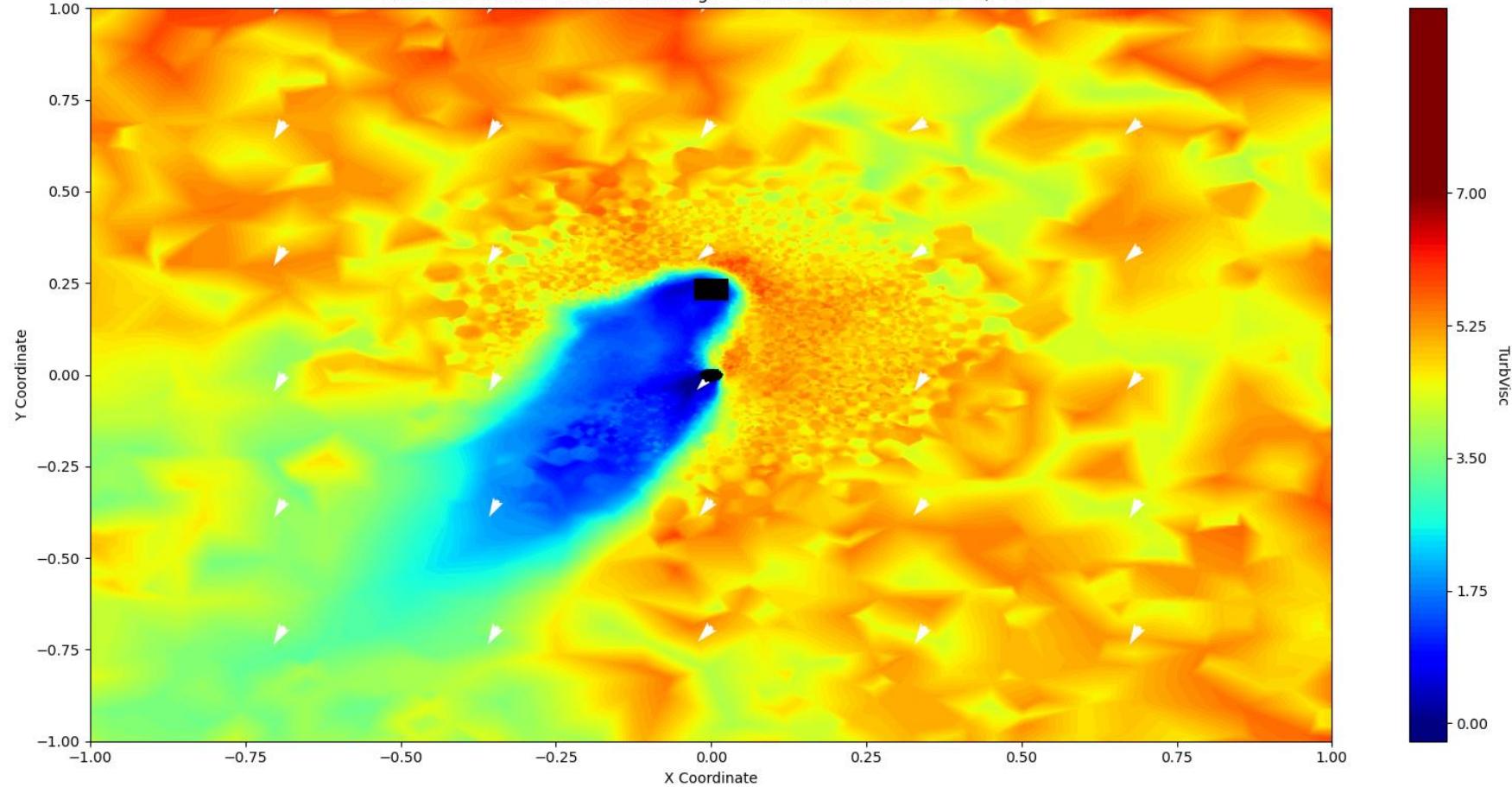
TurbVisc in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



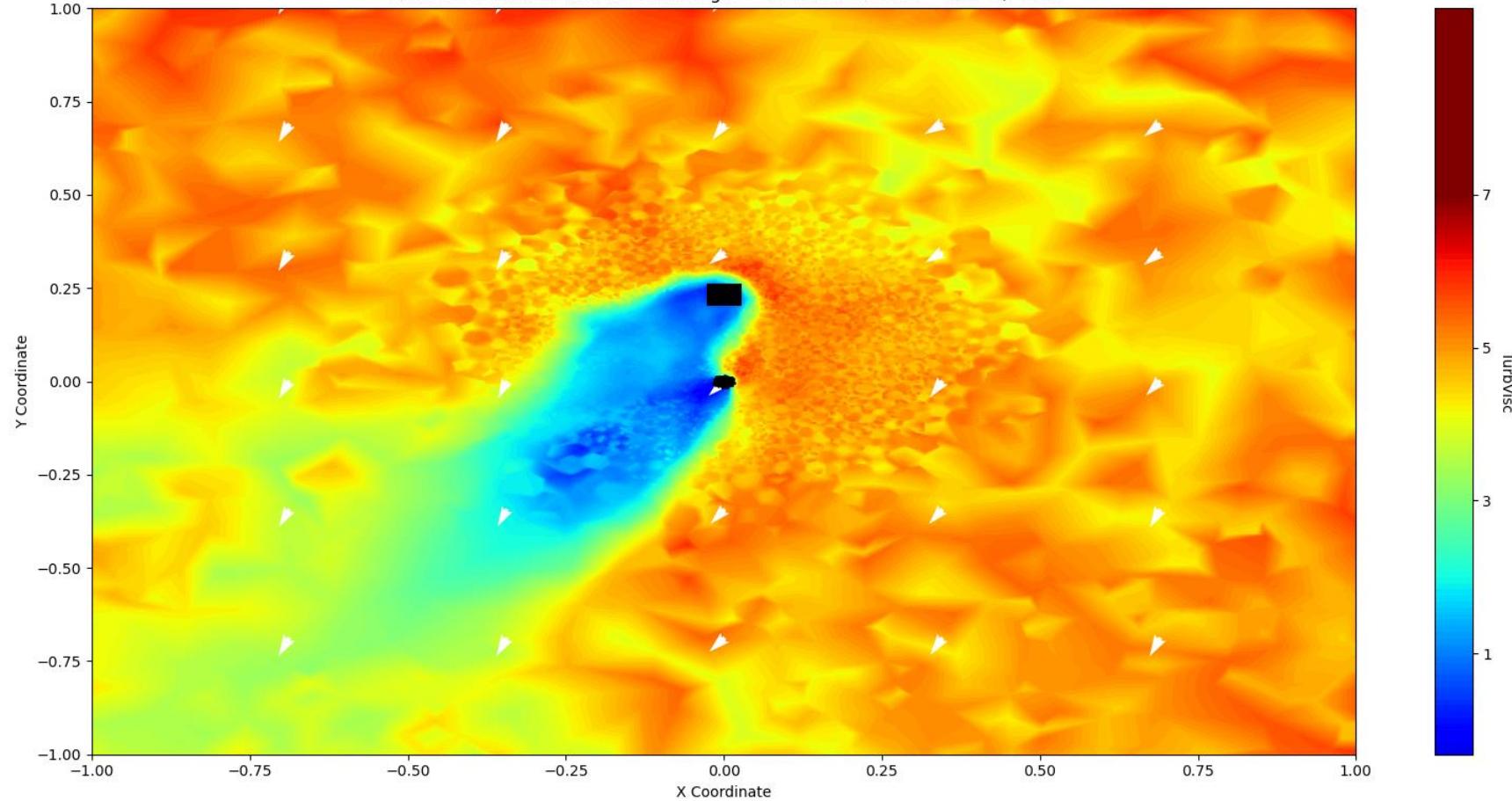
TurbVisc in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



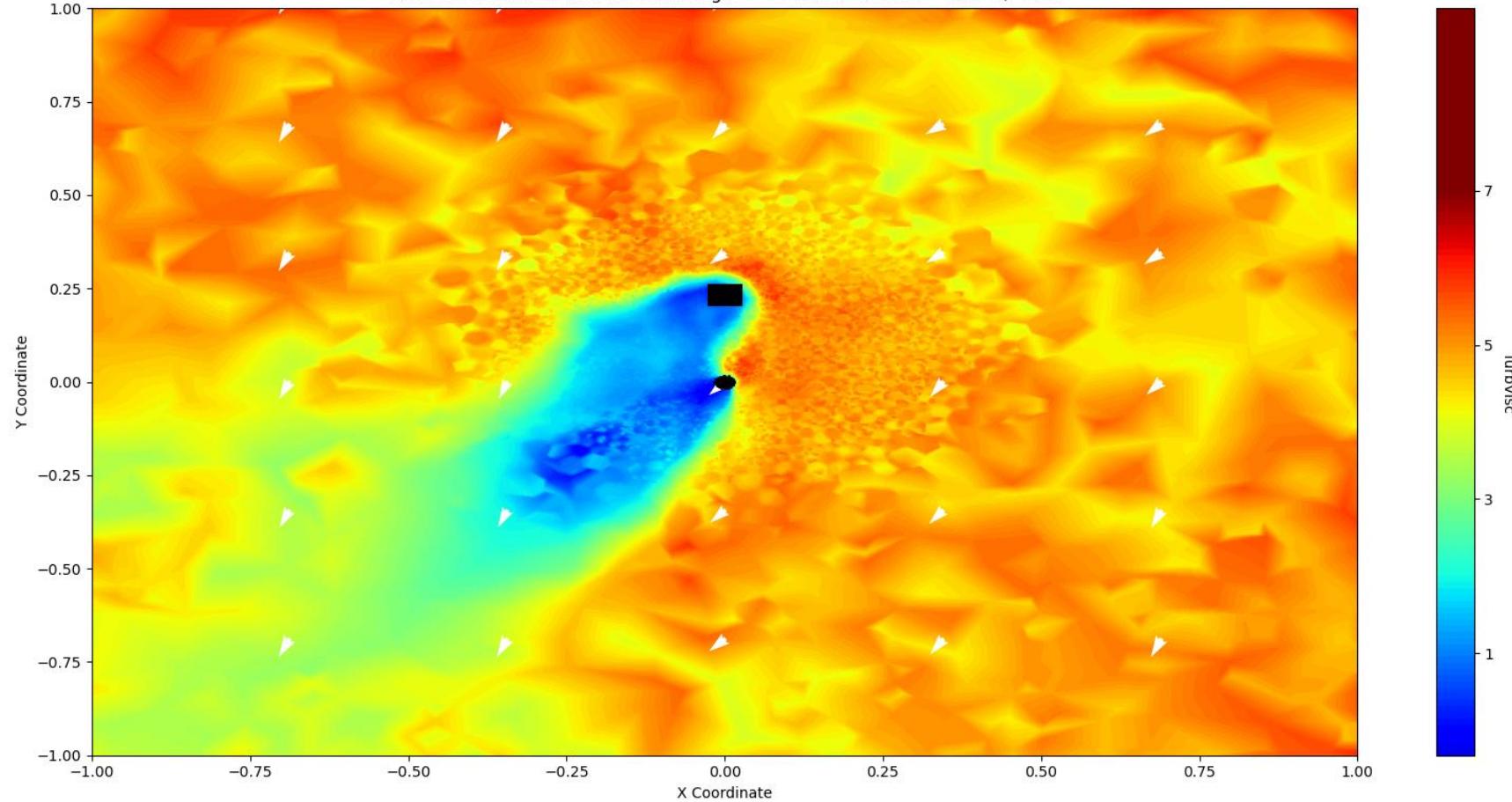
TurbVisc in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



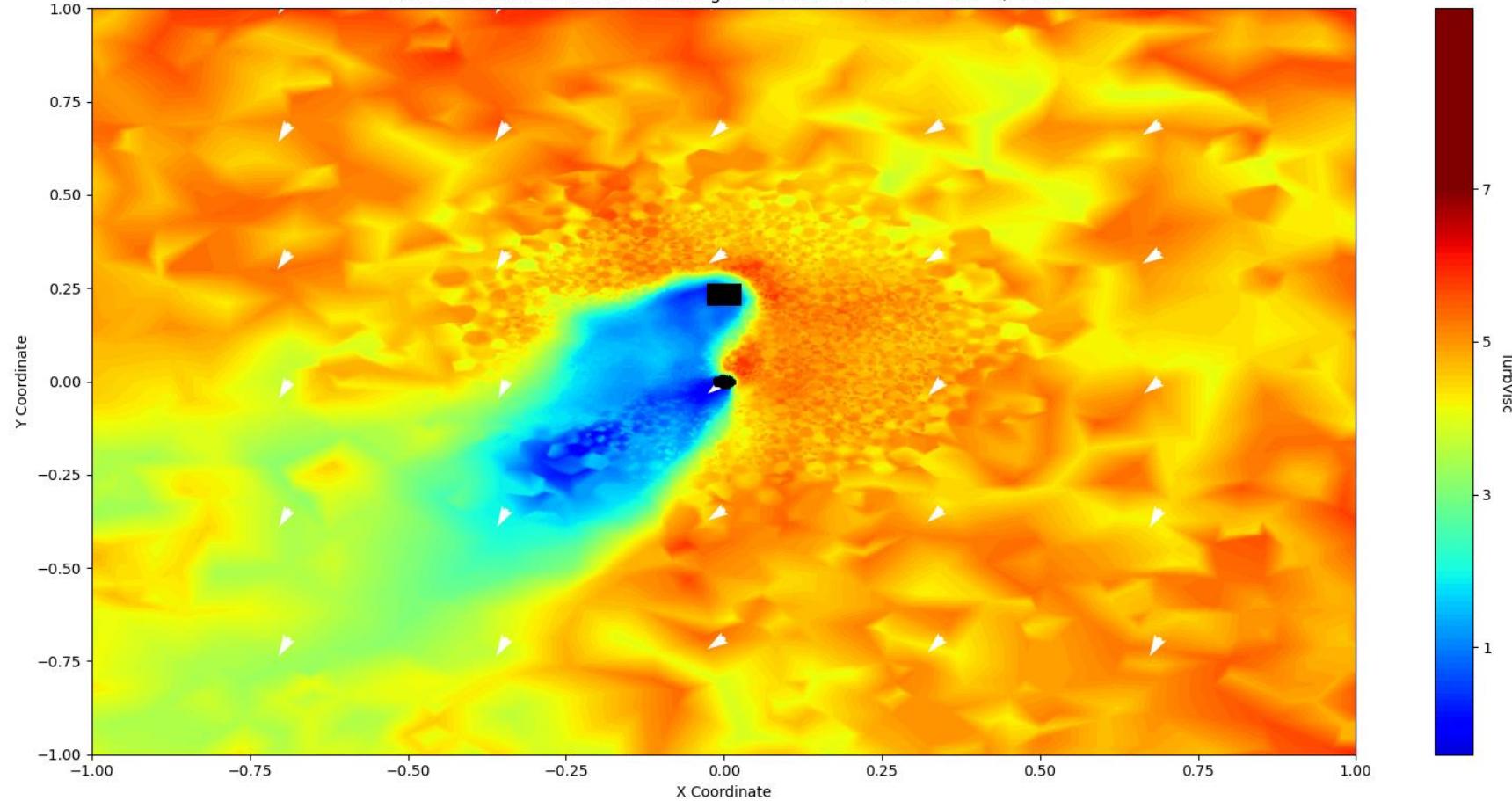
TurbVisc in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



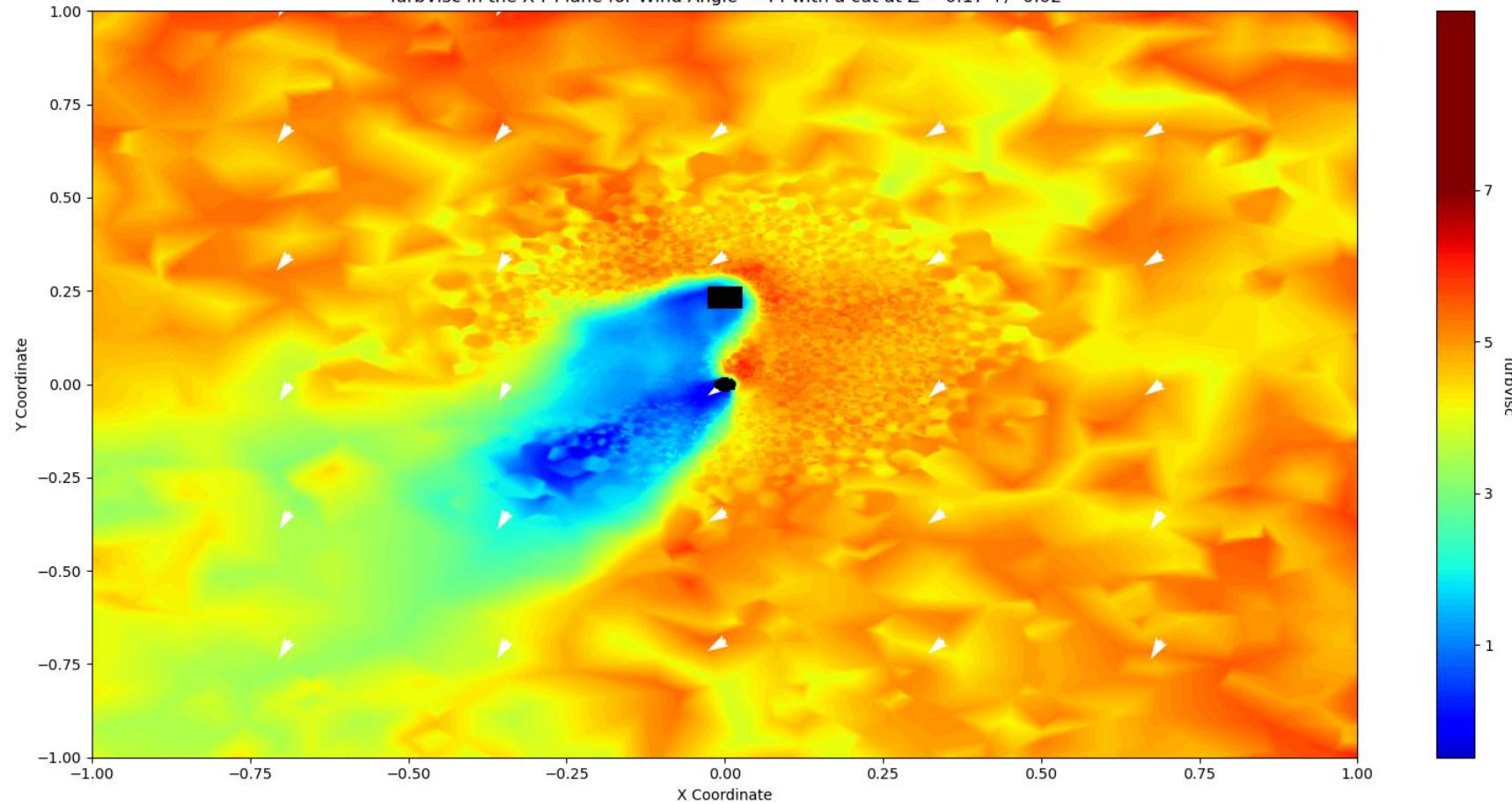
TurbVisc in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



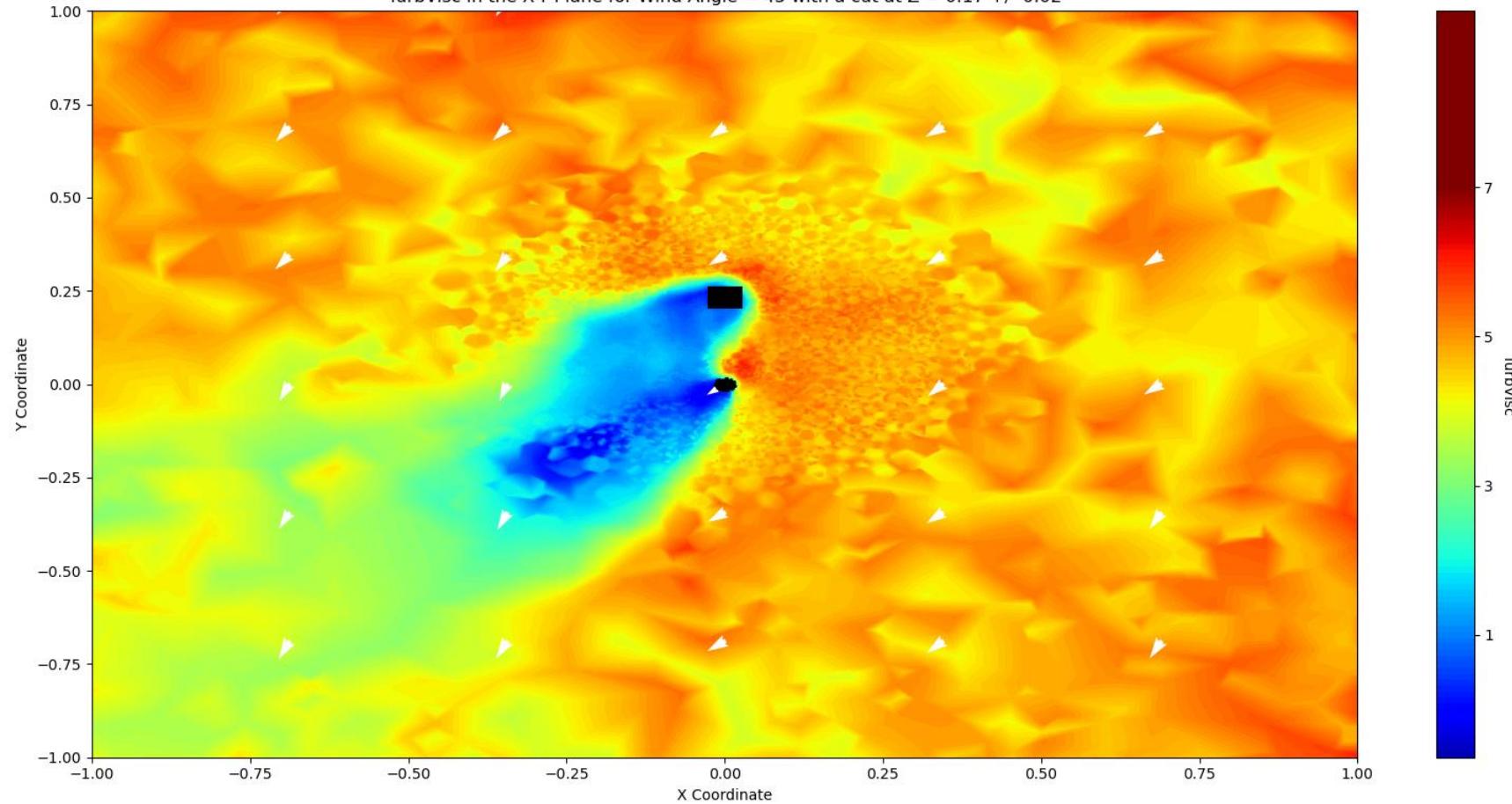
TurbVisc in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



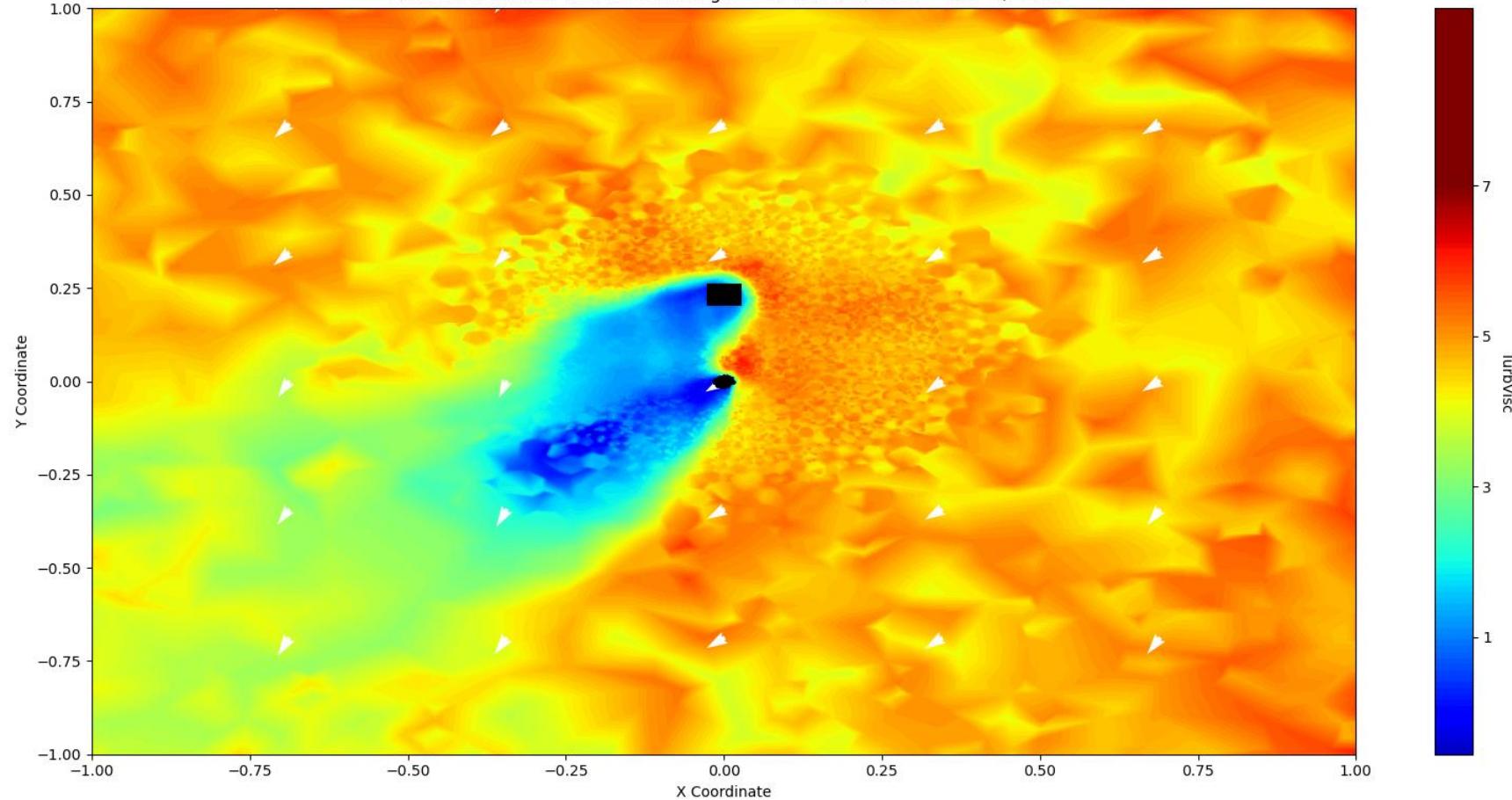
TurbVisc in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



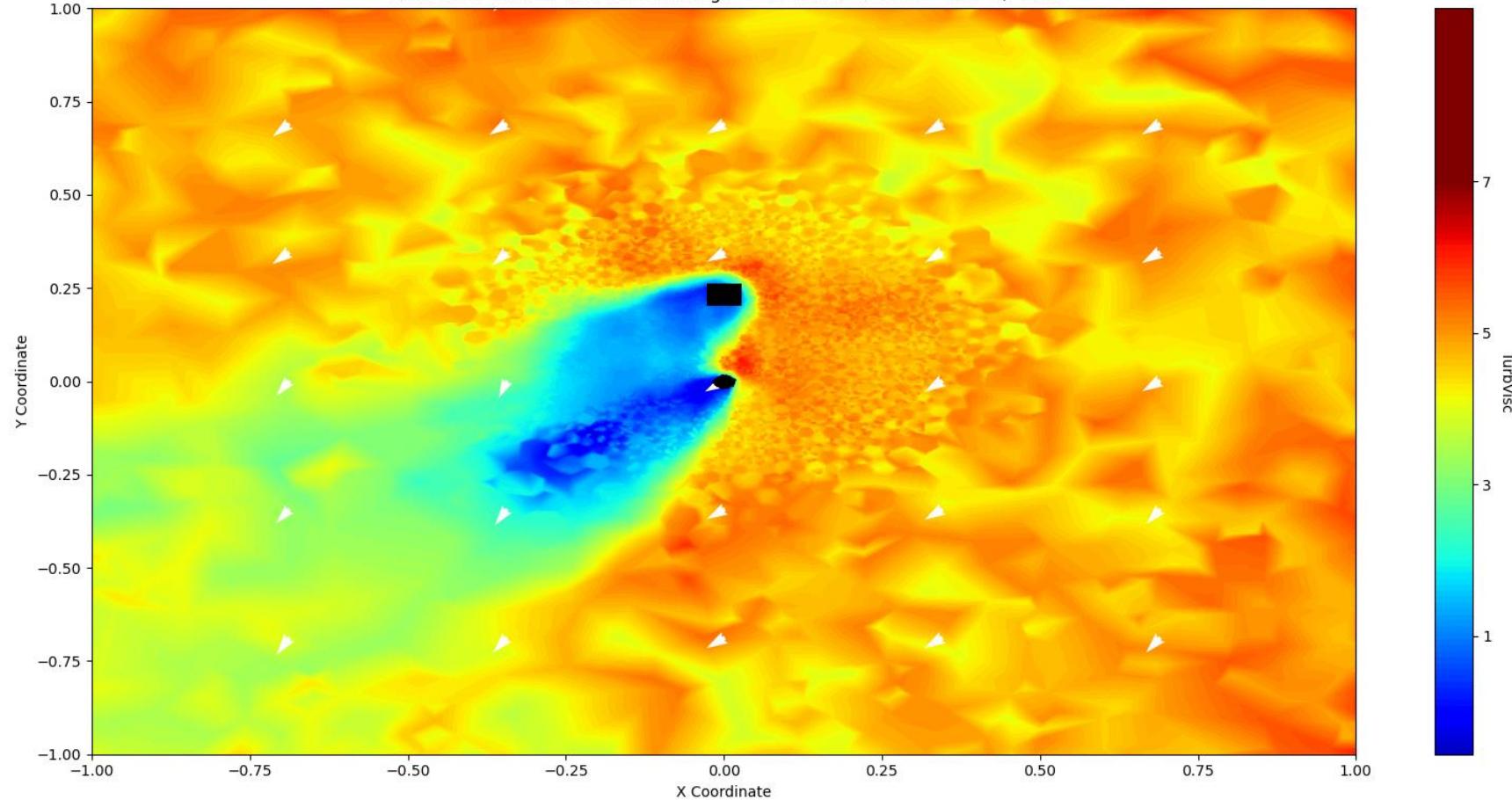
TurbVisc in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



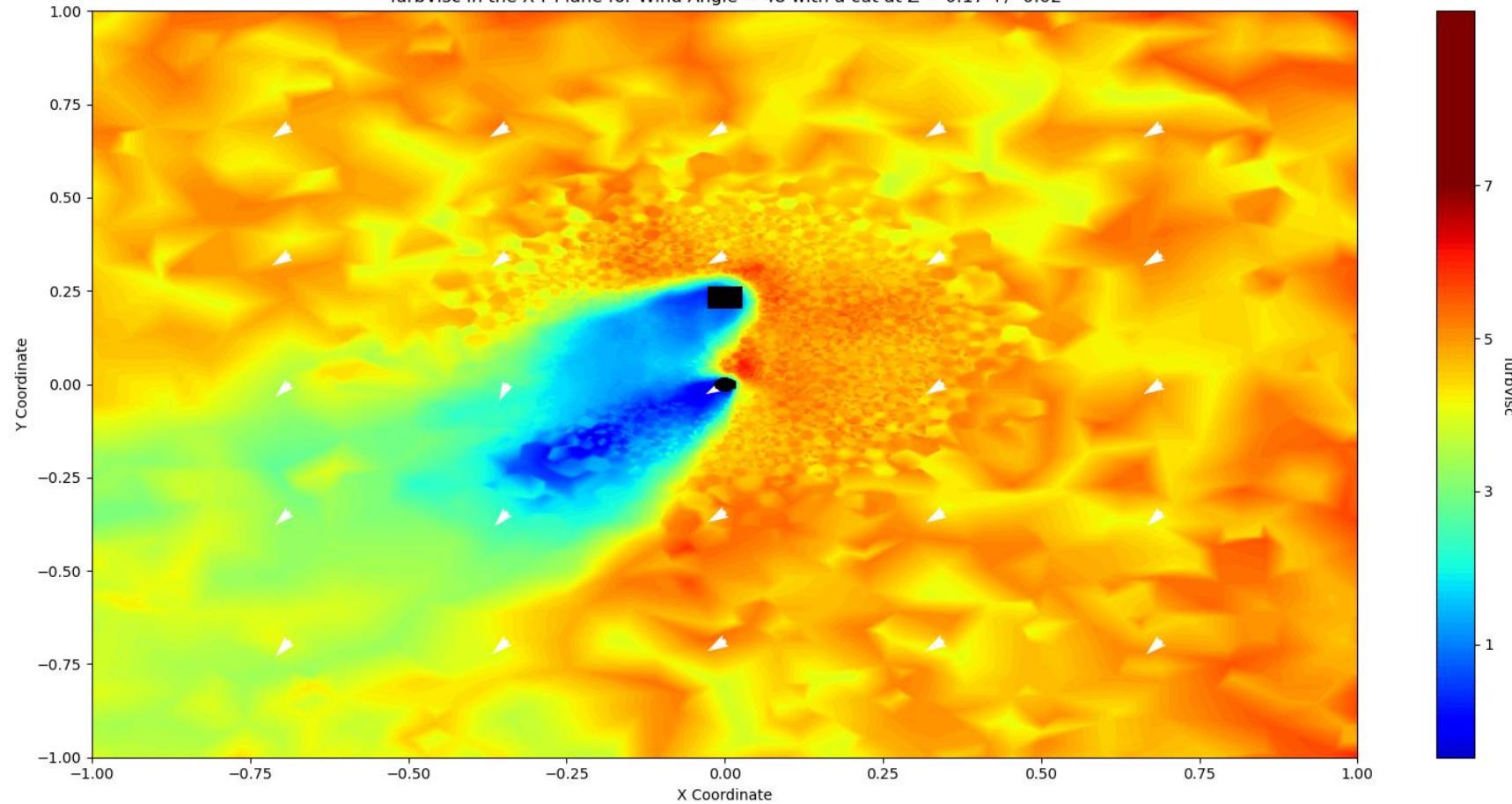
TurbVisc in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



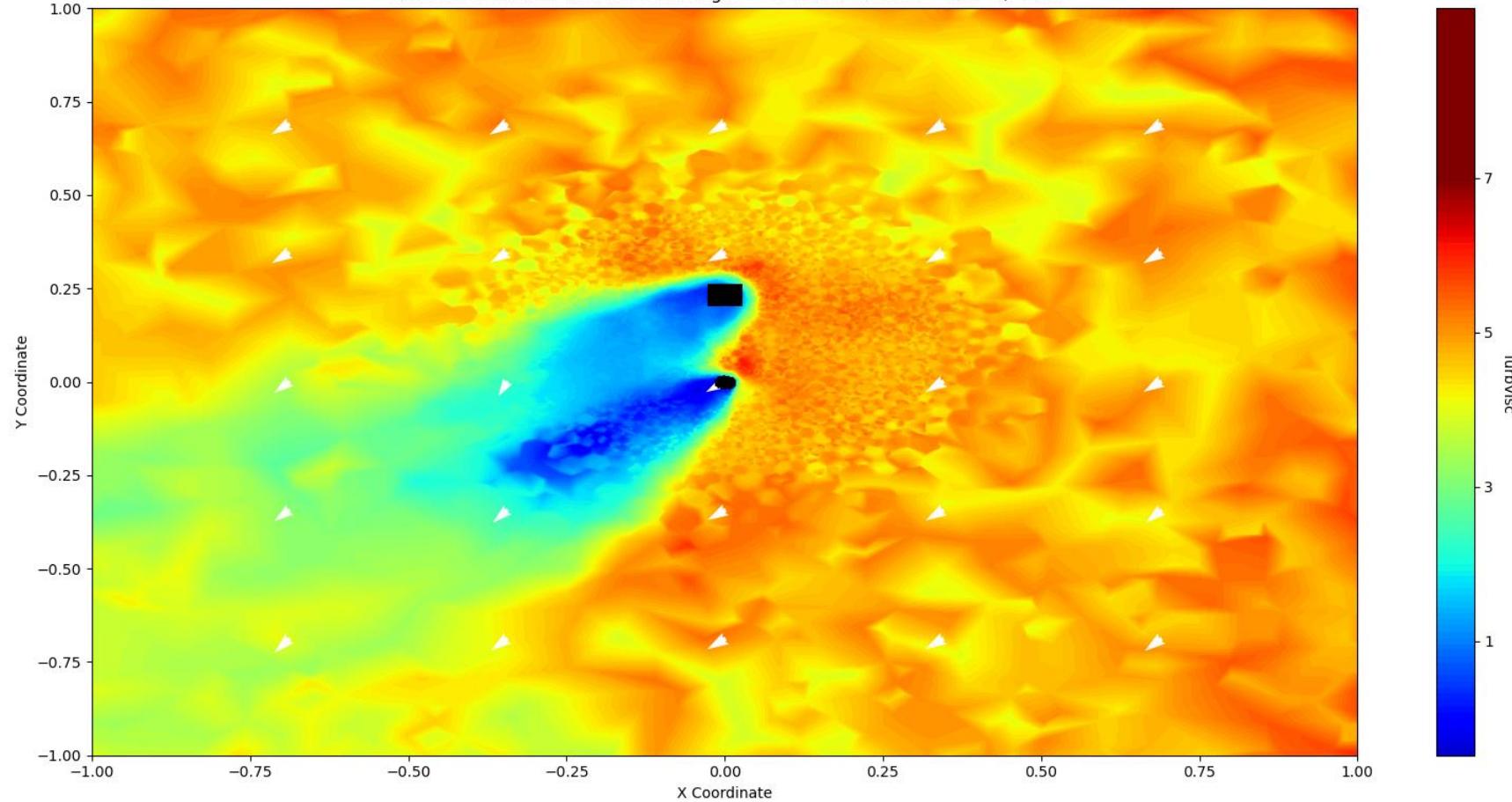
TurbVisc in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



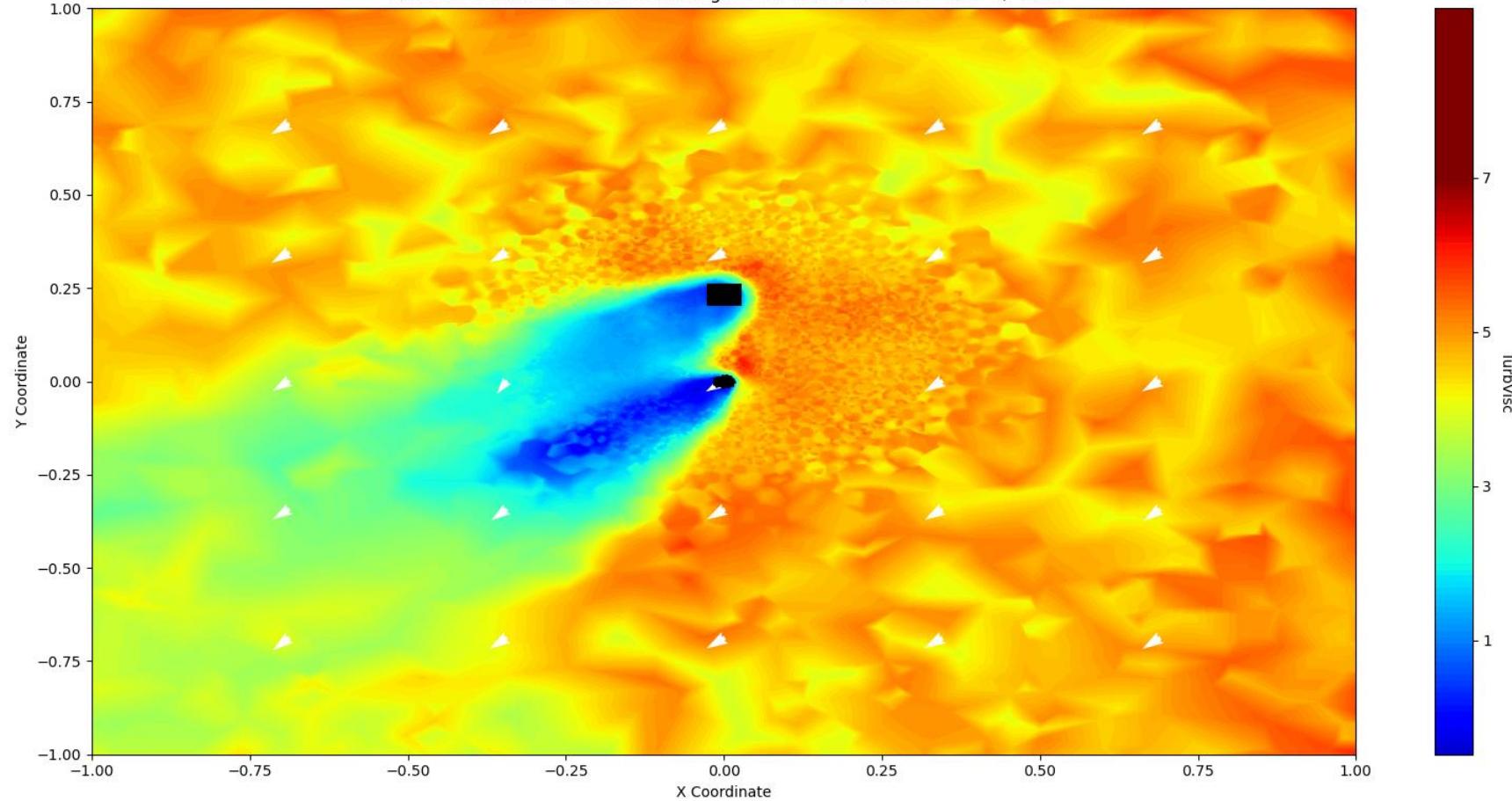
TurbVisc in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



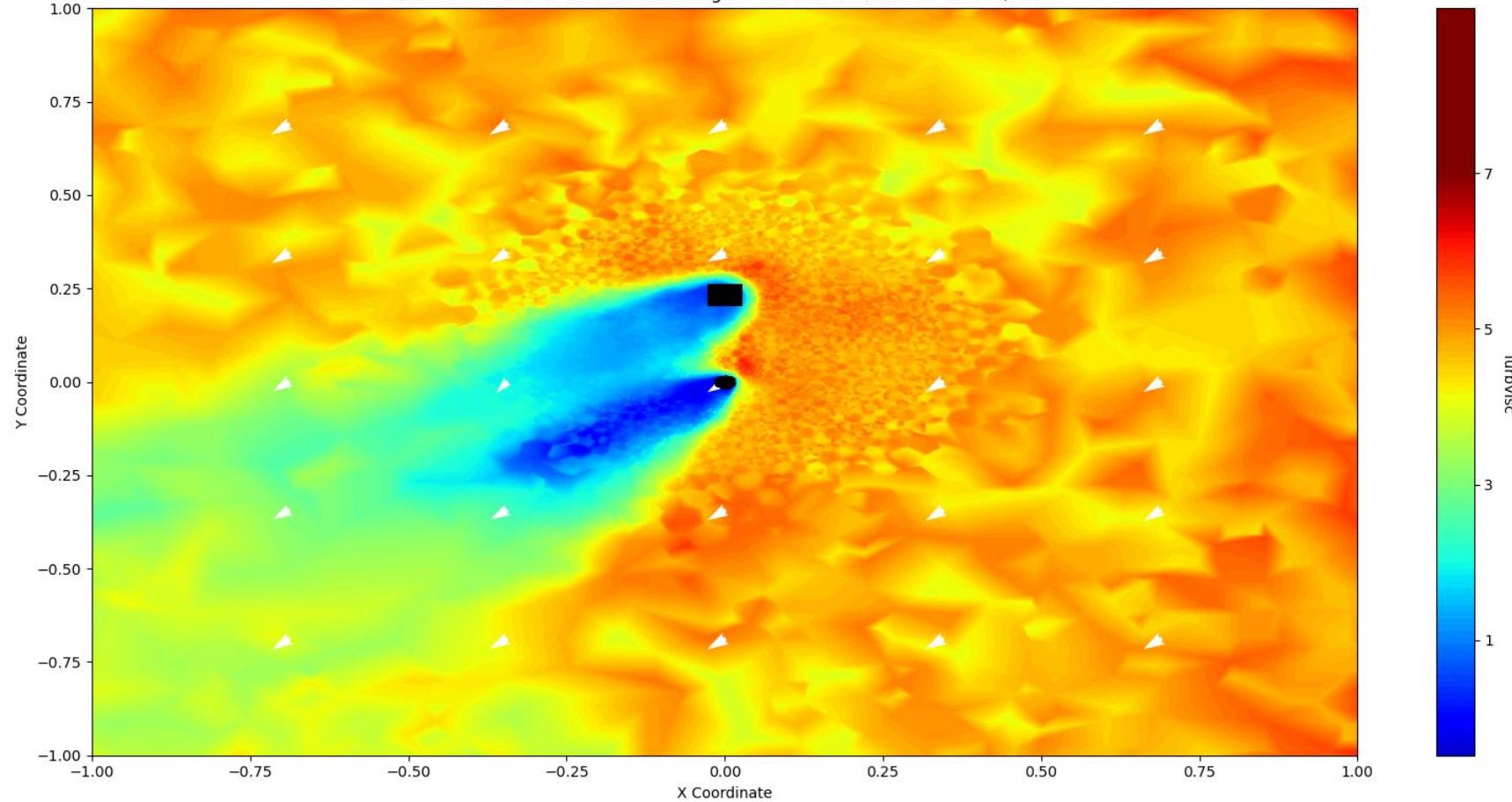
TurbVisc in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



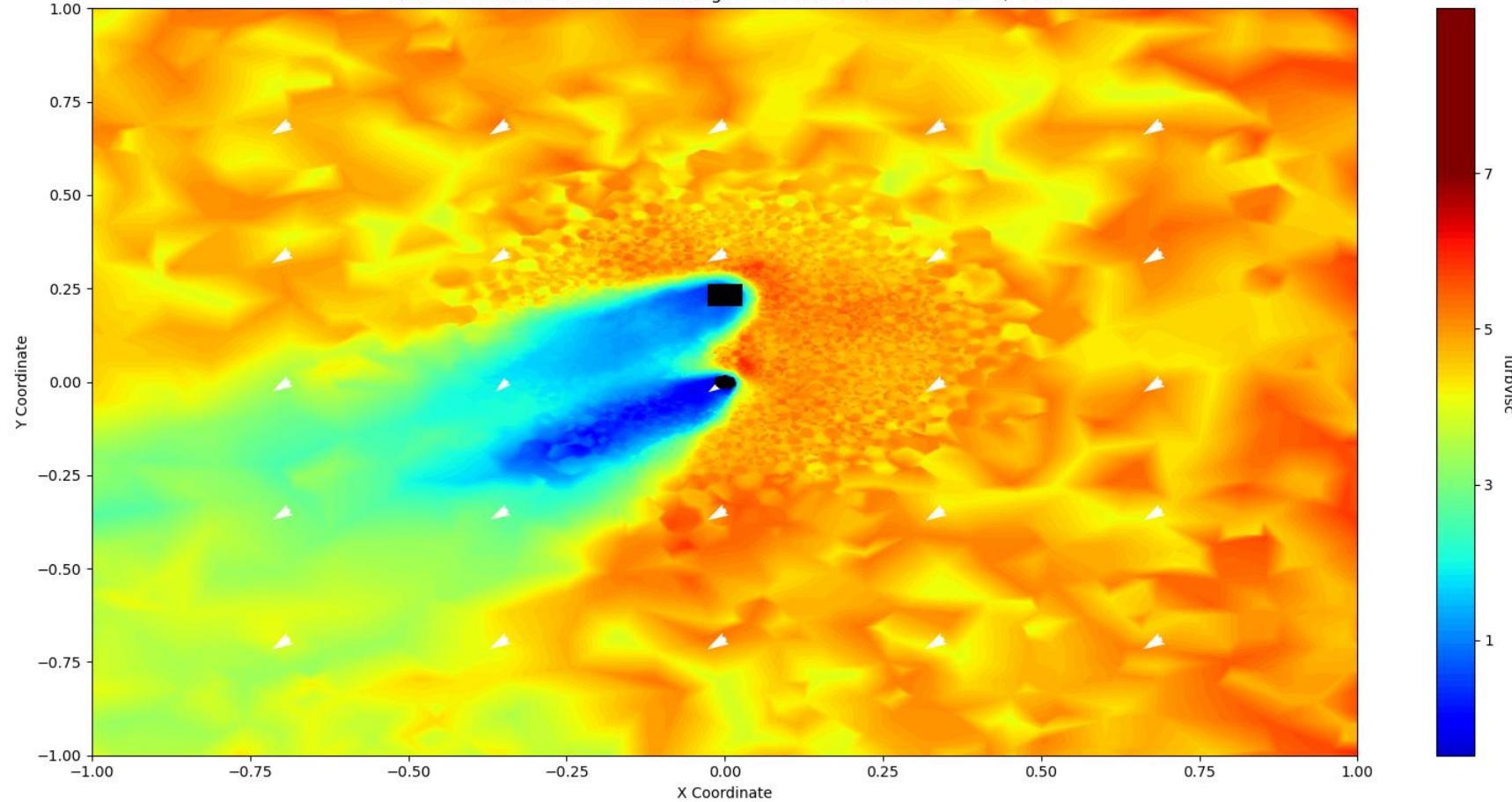
TurbVisc in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



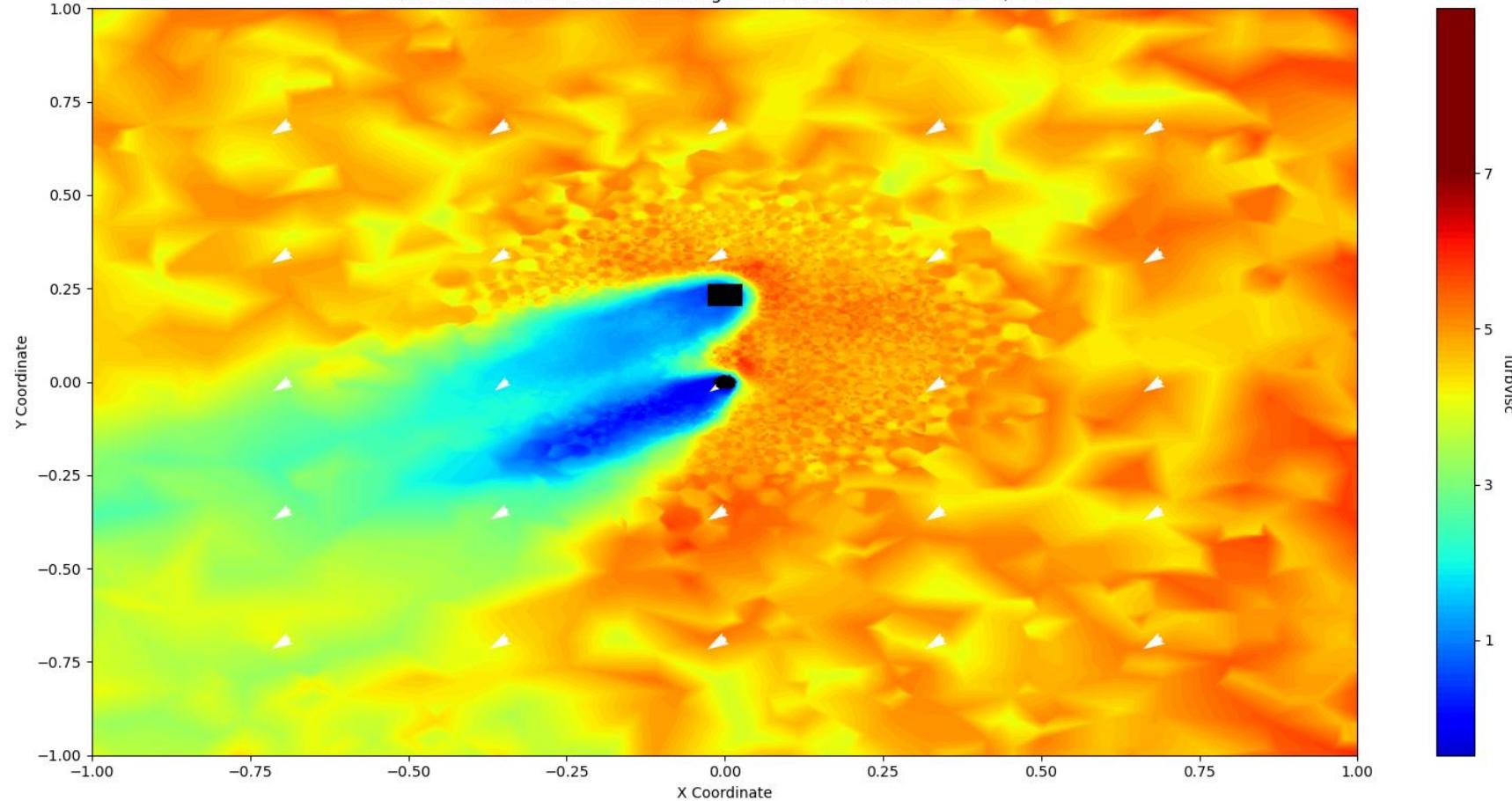
TurbVisc in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



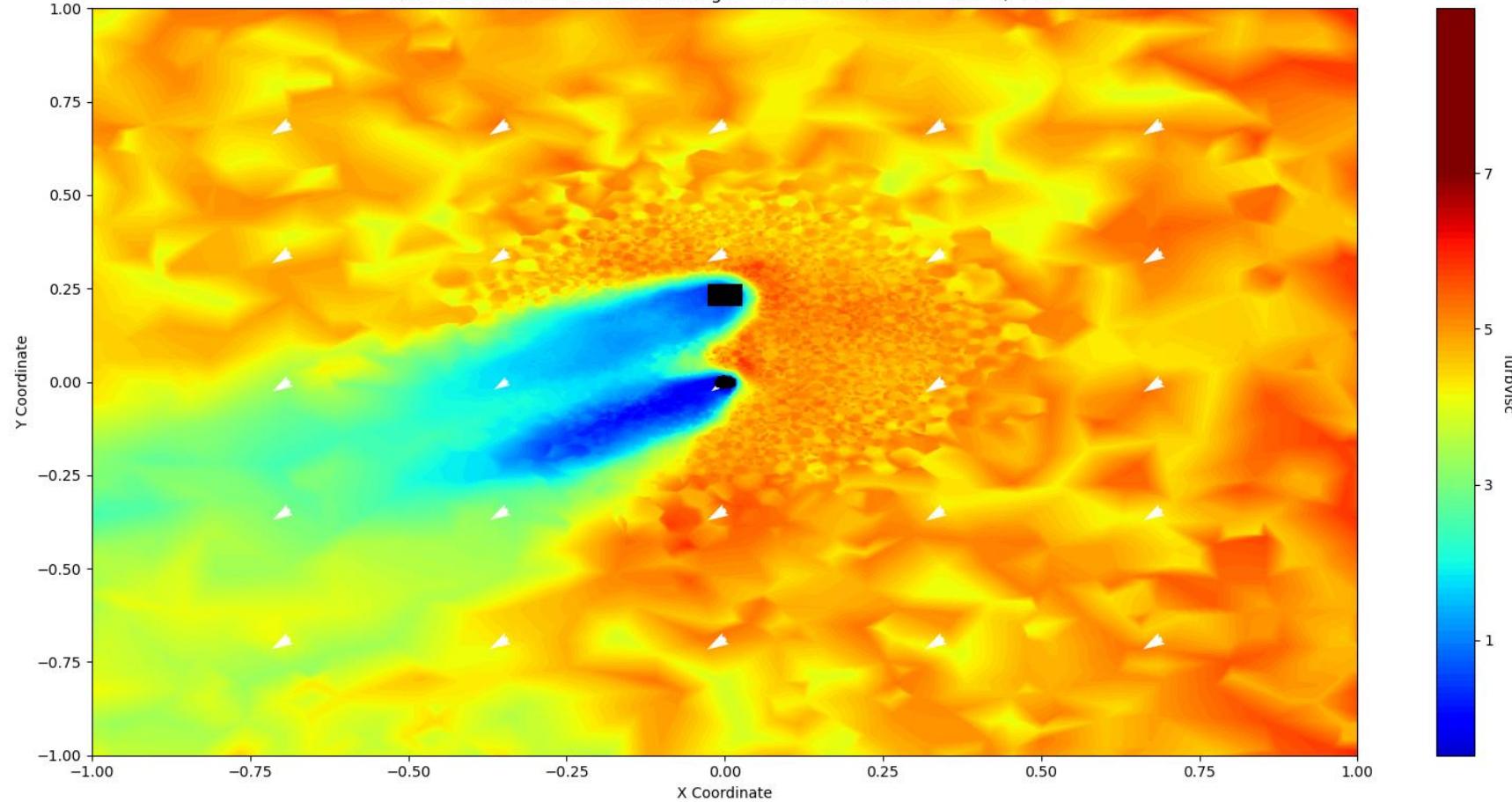
TurbVisc in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



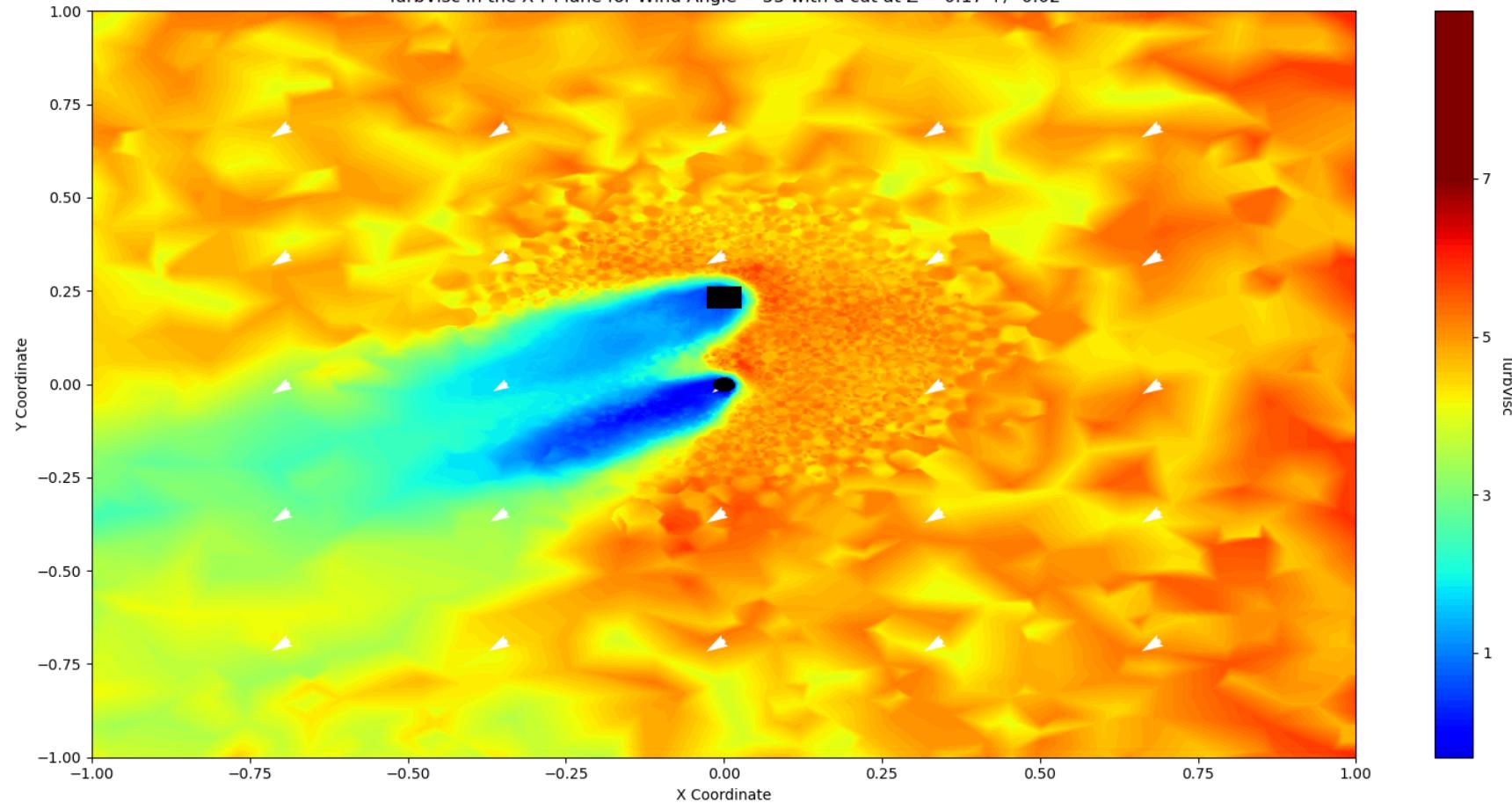
TurbVisc in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



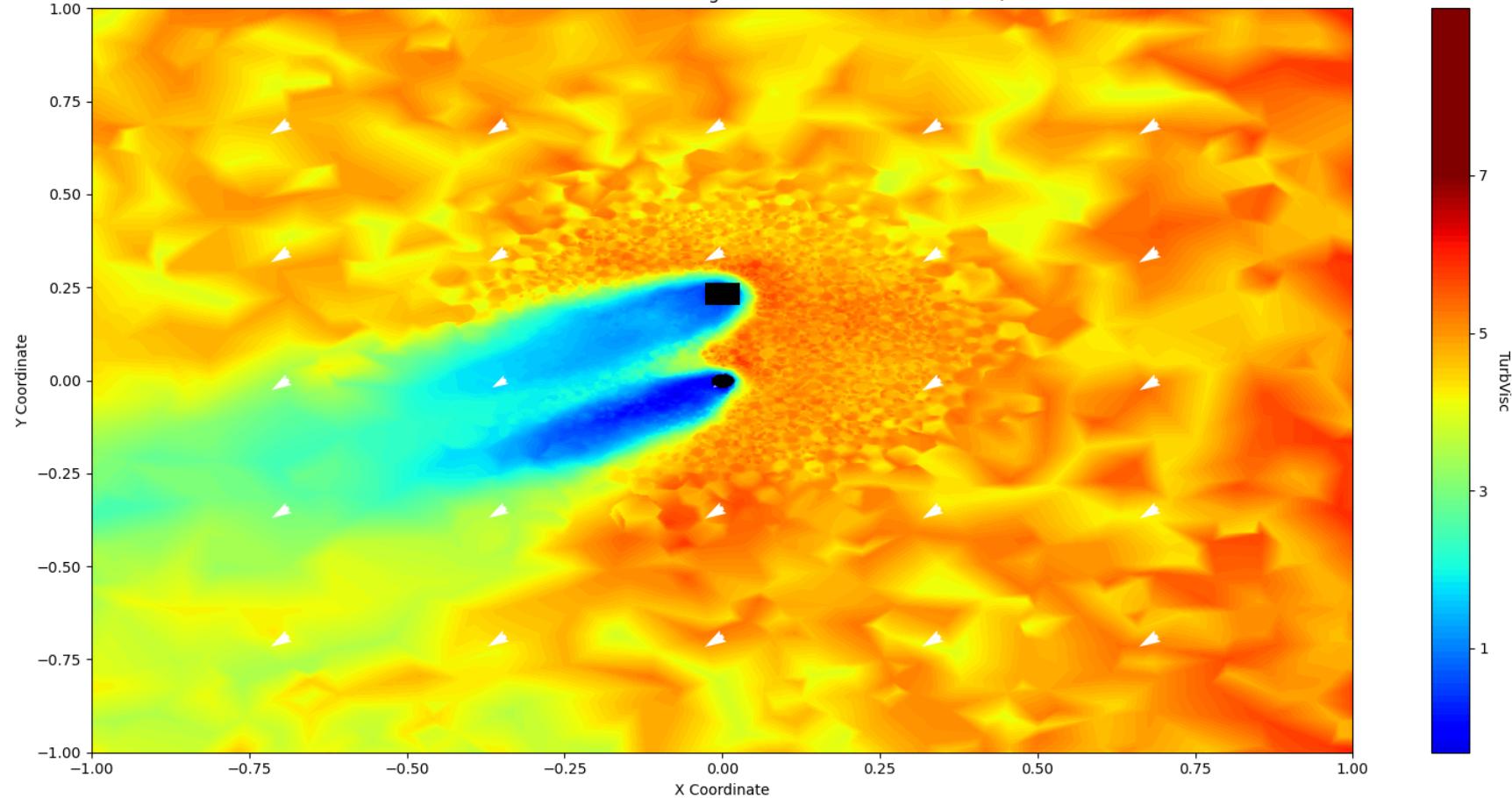
TurbVisc in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



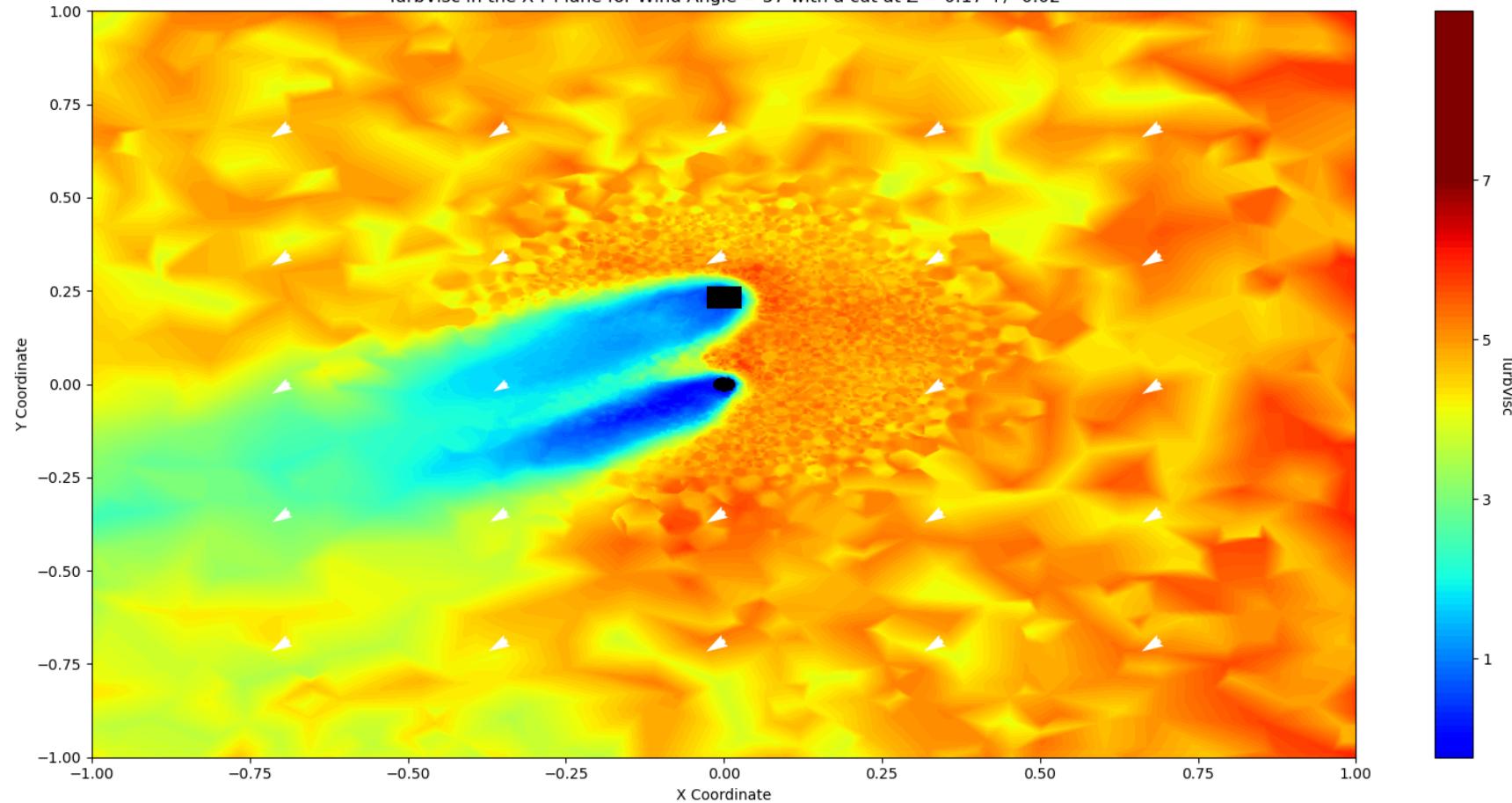
TurbVisc in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



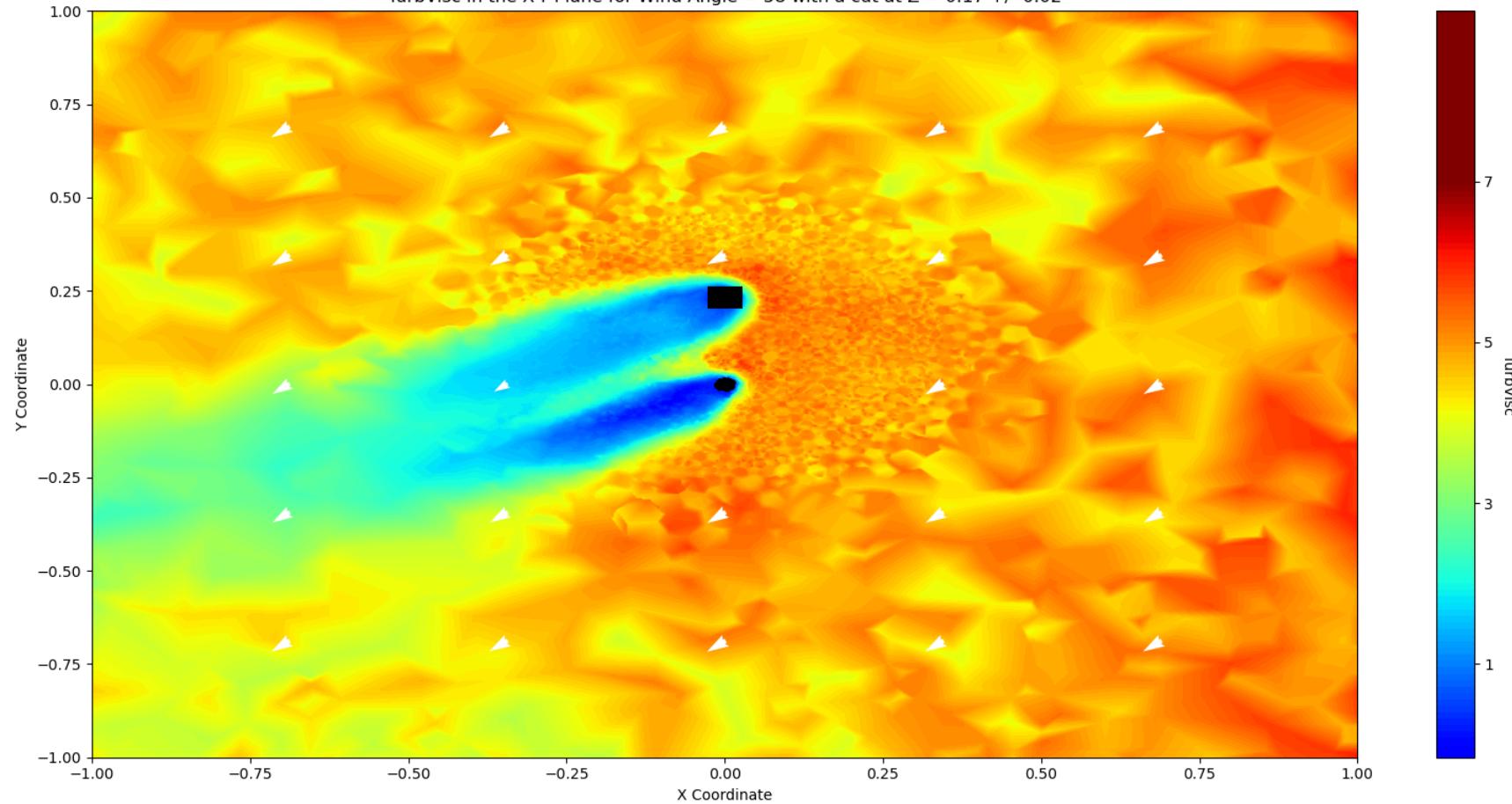
TurbVisc in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



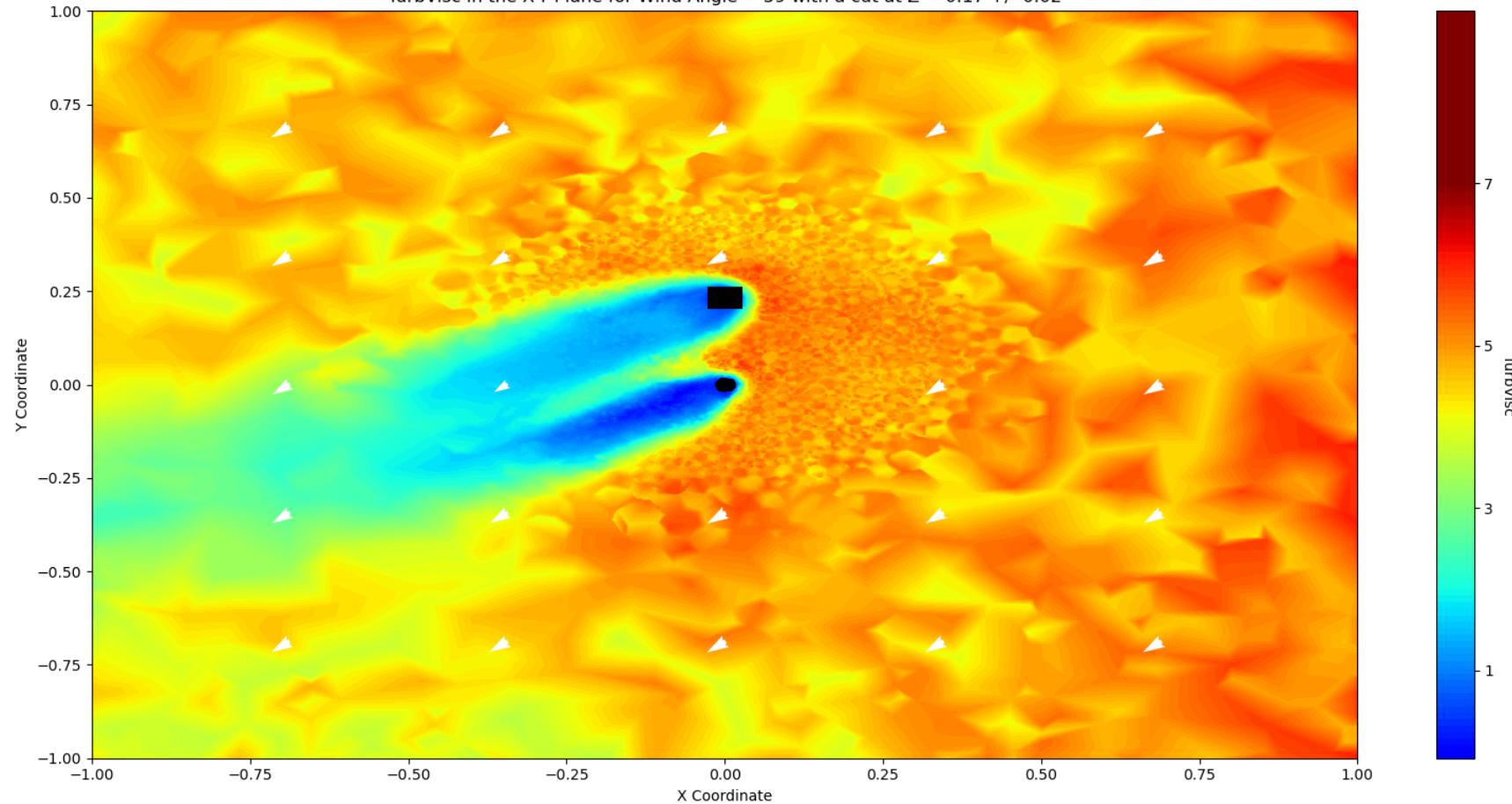
TurbVisc in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



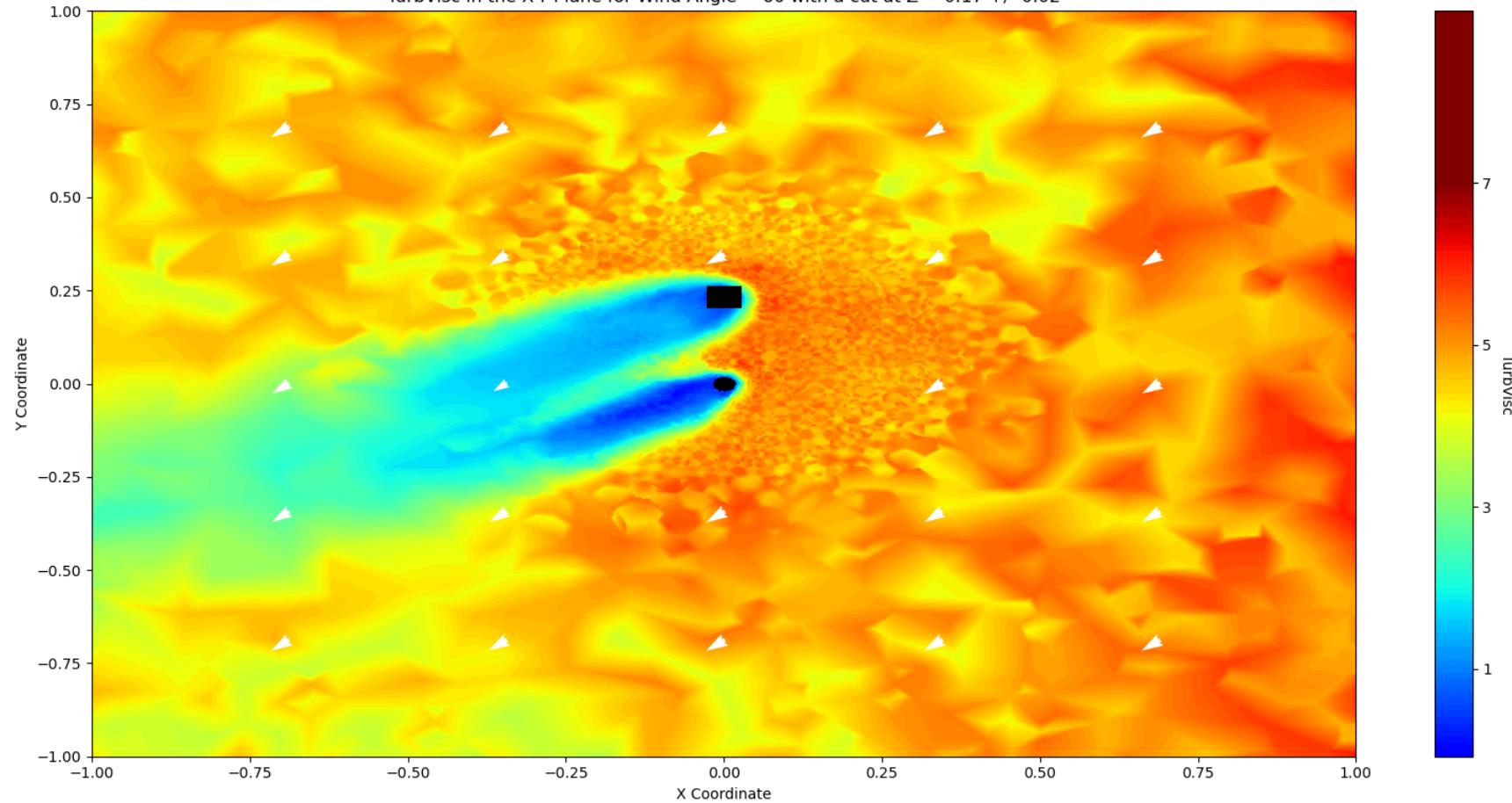
TurbVisc in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



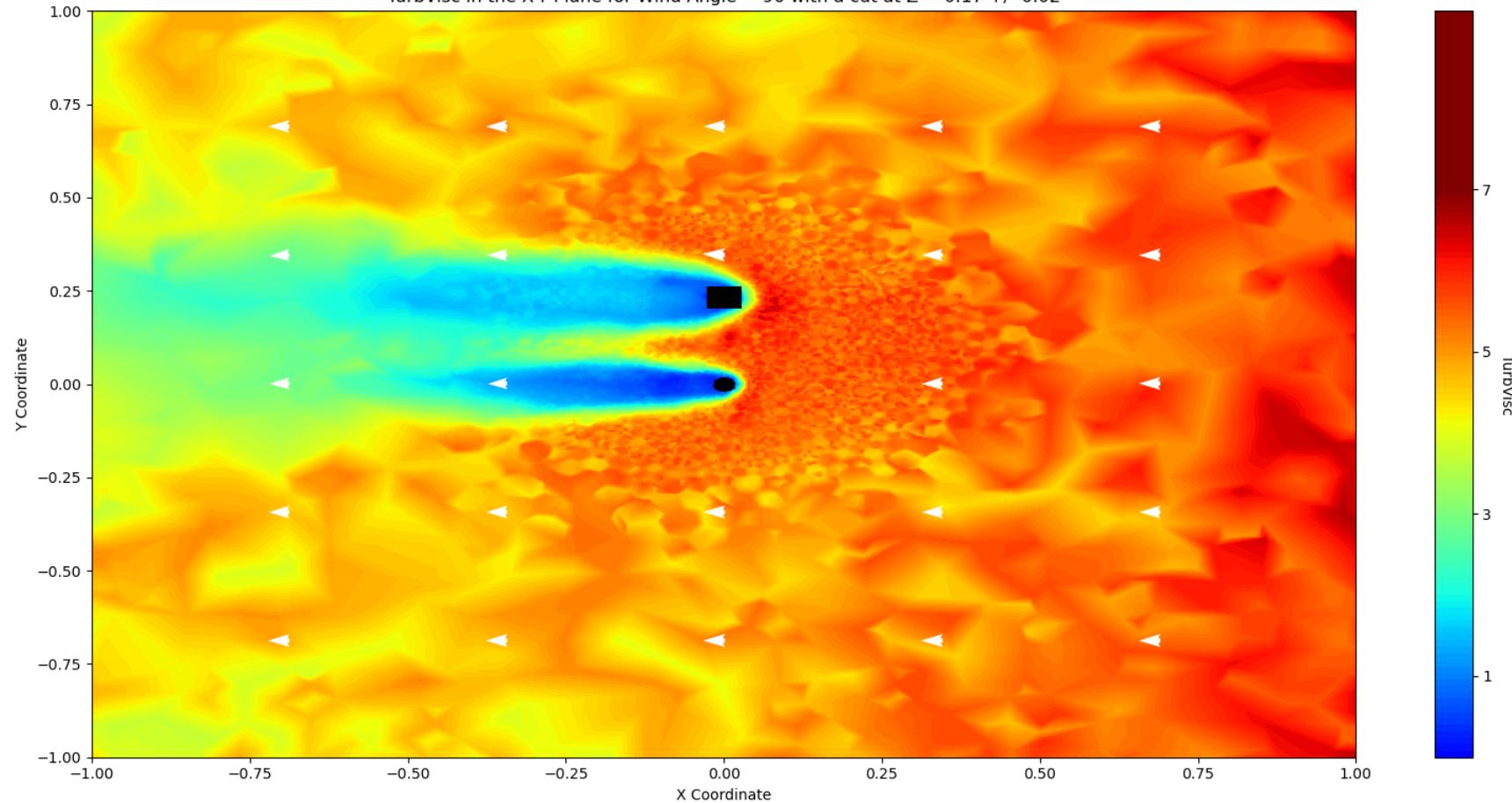
TurbVisc in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



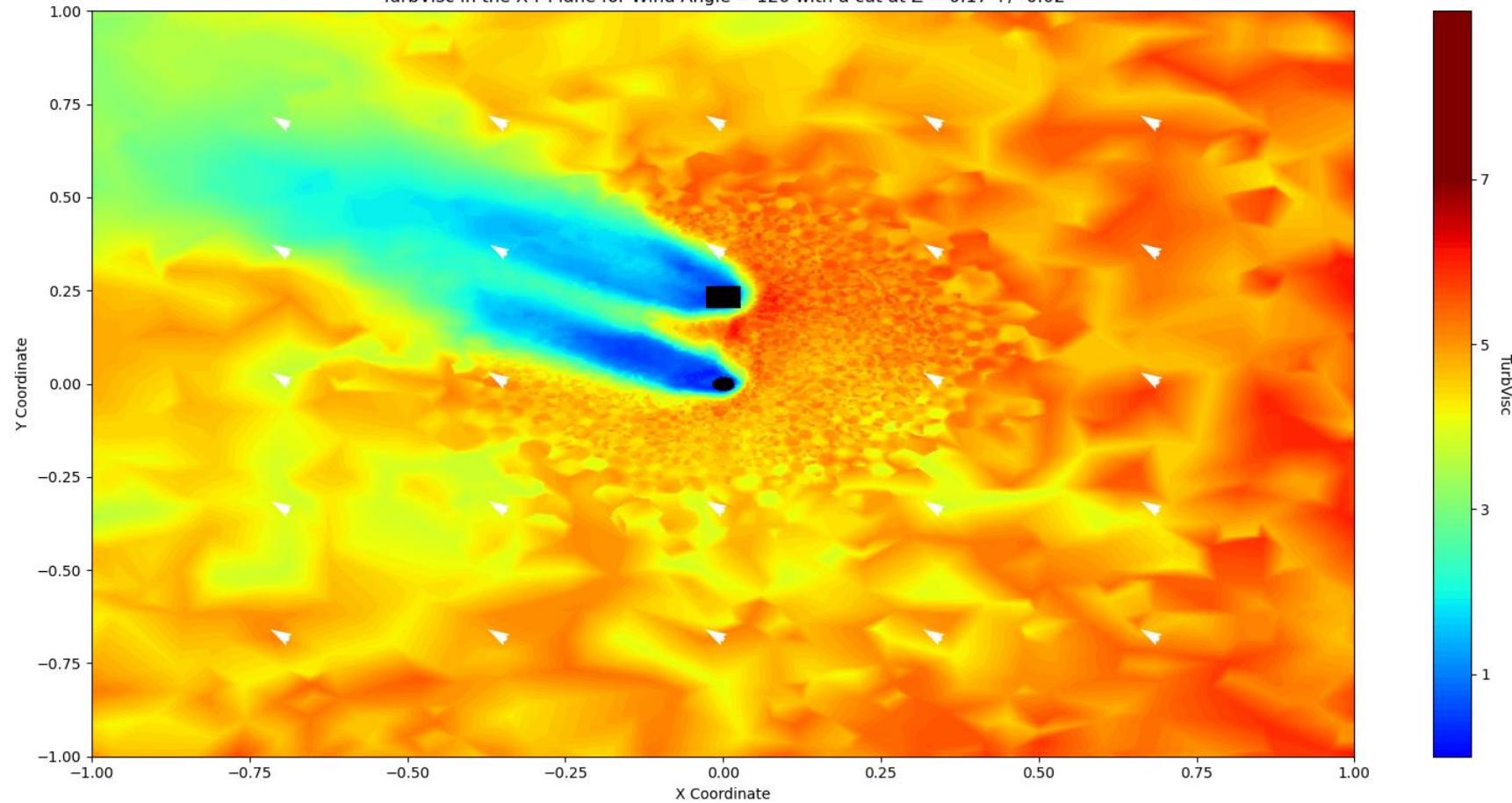
TurbVisc in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



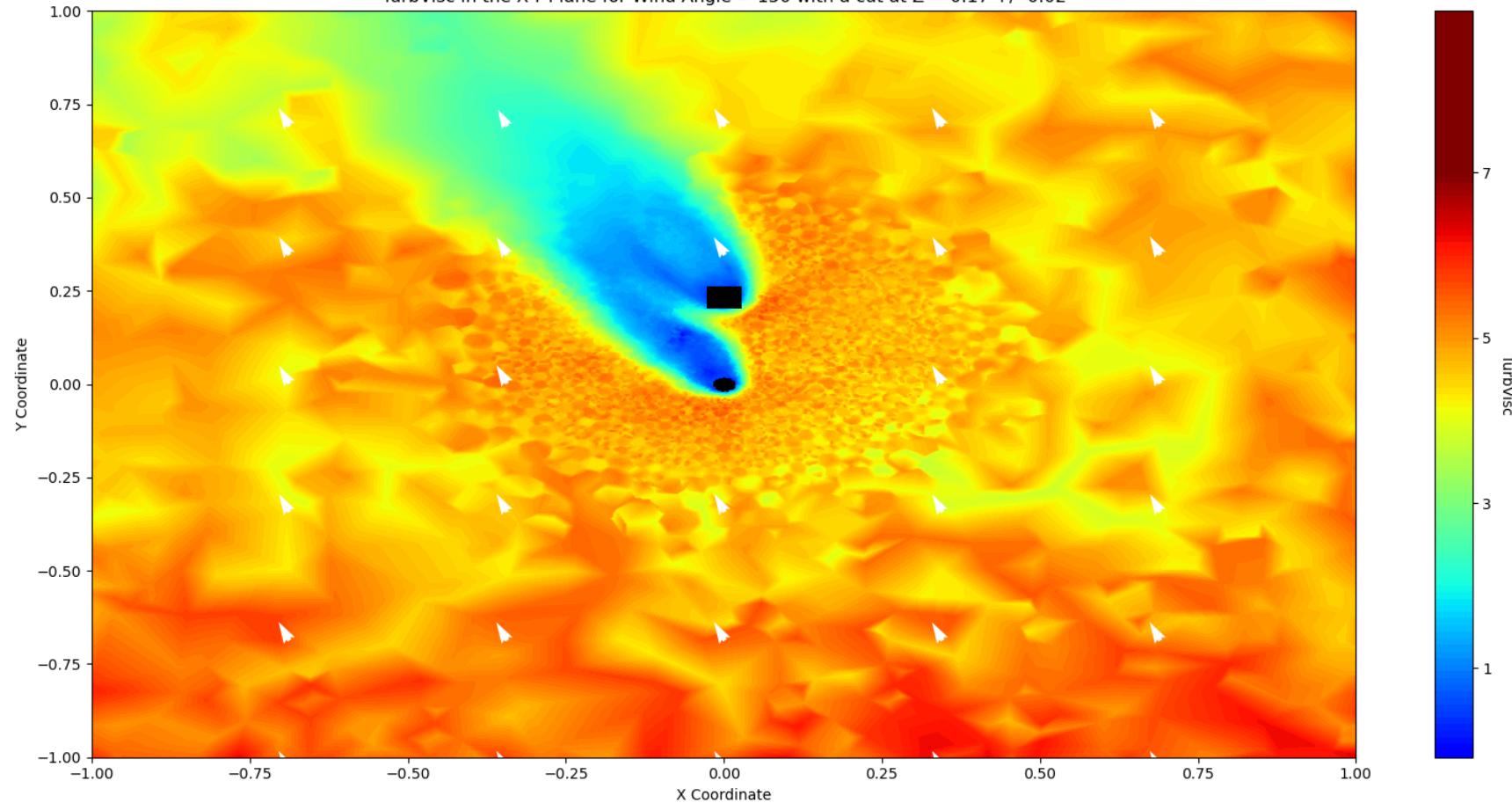
TurbVisc in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



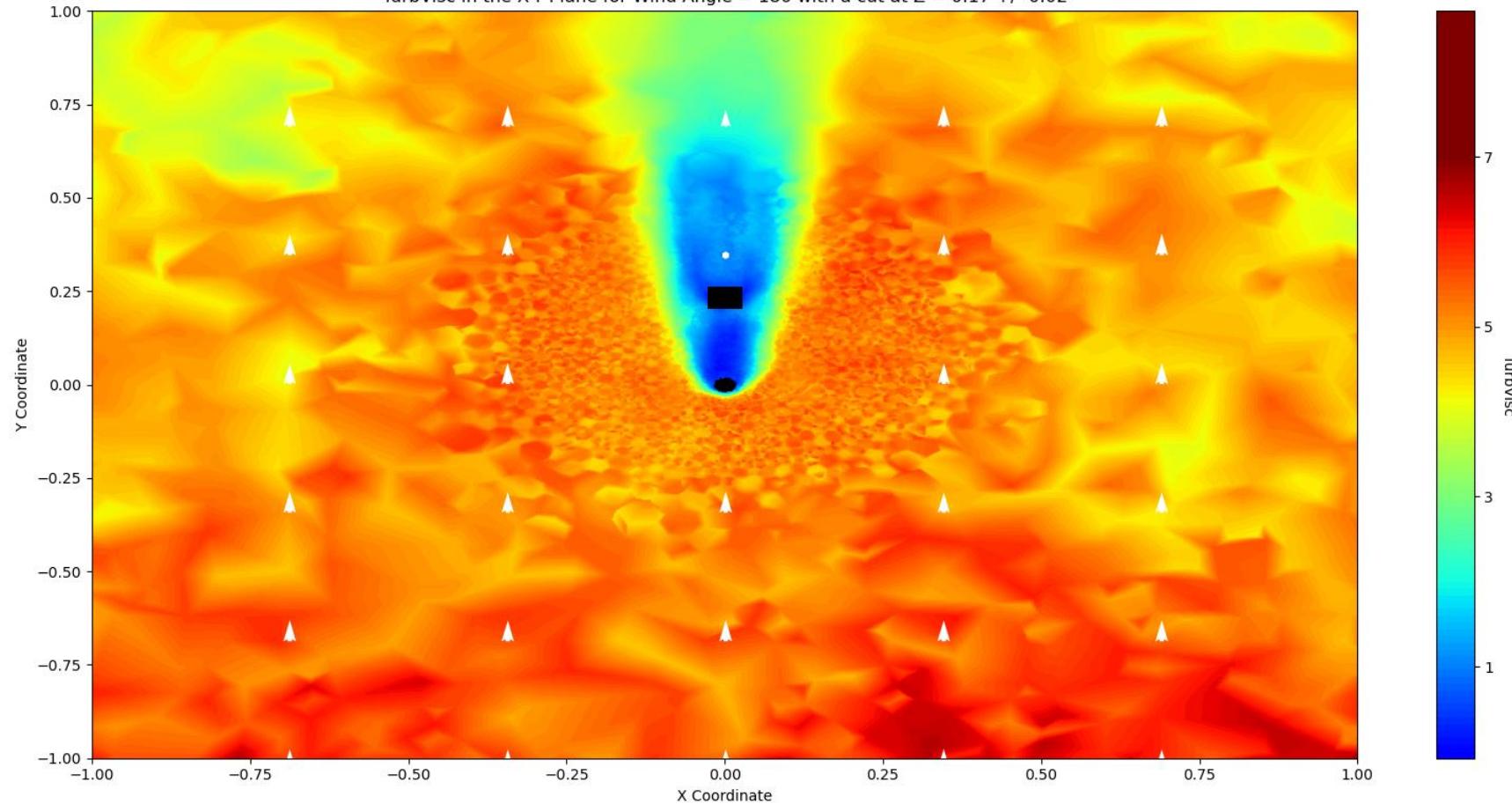
TurbVisc in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



Progress so far - Data Loss + Cont Loss
(WITHOUT Boundary Conditions imposed)
(Adam Optimizer)

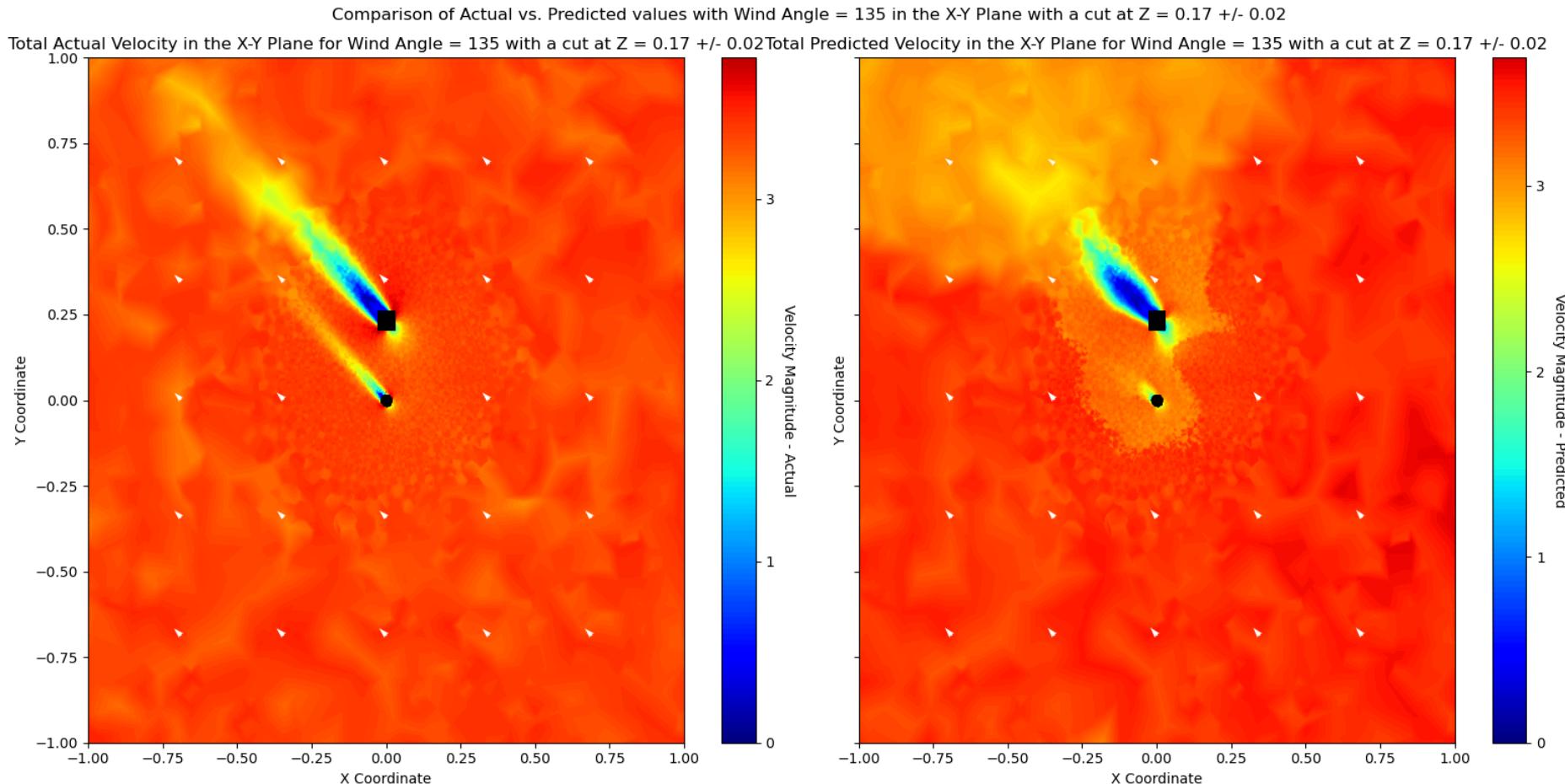
Threshold = 1E-5 (4660 Epochs, not completed), Google Colab

Scripts v3 – PREDICTING (135 DEG)

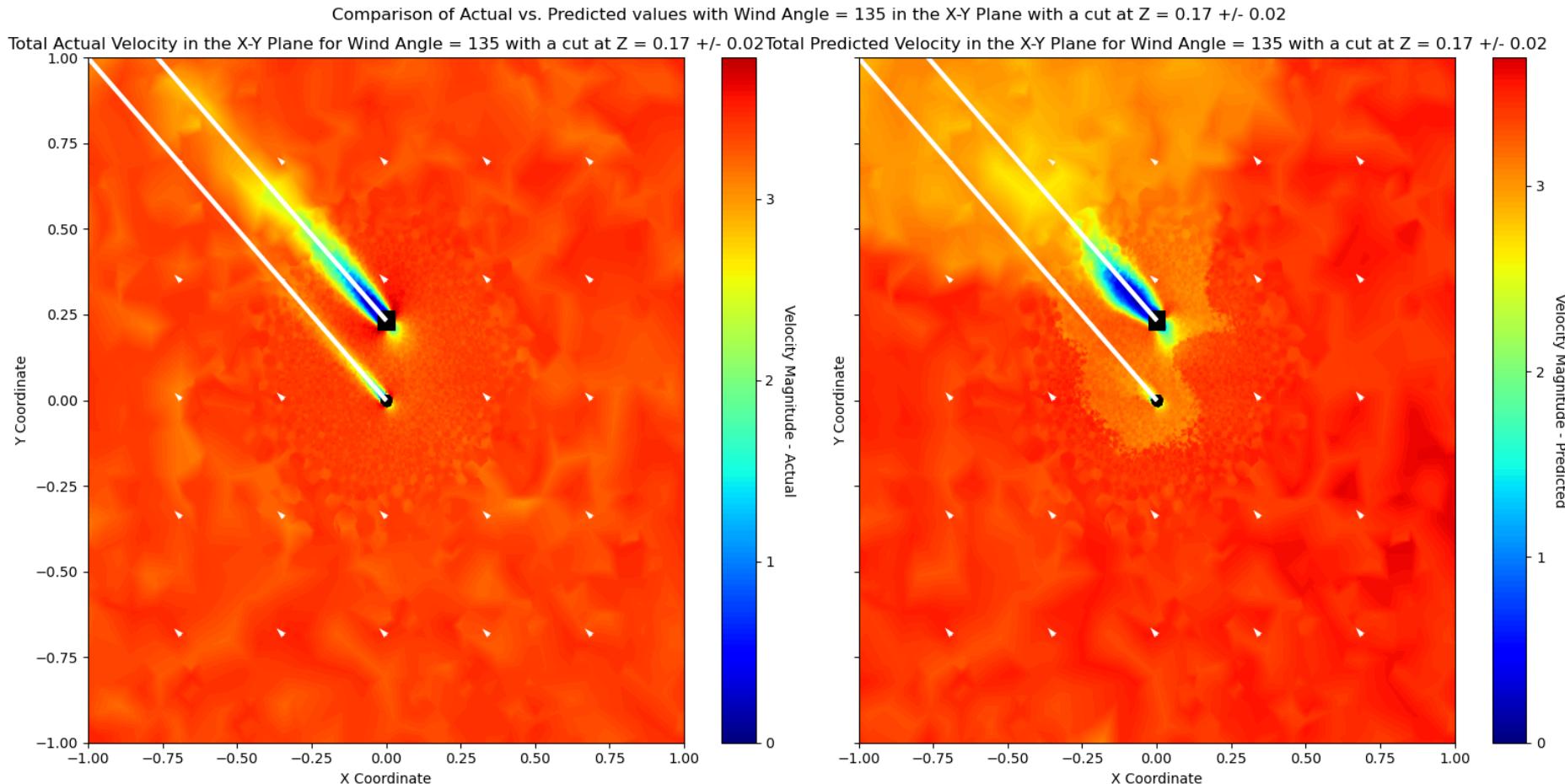
Progress so far - Data + Cont Loss (Adam Optimizer)
Threshold = 1E-5 (4660 Epochs, so far...), Google Colab
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	0.264865	0.51465	0.303361	0.843309
Velocity:0	0.050552	0.224838	0.165251	0.950401
Velocity:1	0.16956	0.411776	0.364932	0.835225
Velocity:2	0.004823	0.069448	0.023243	0.852572
TurbVisc	0.195052	0.441647	0.305247	0.998579

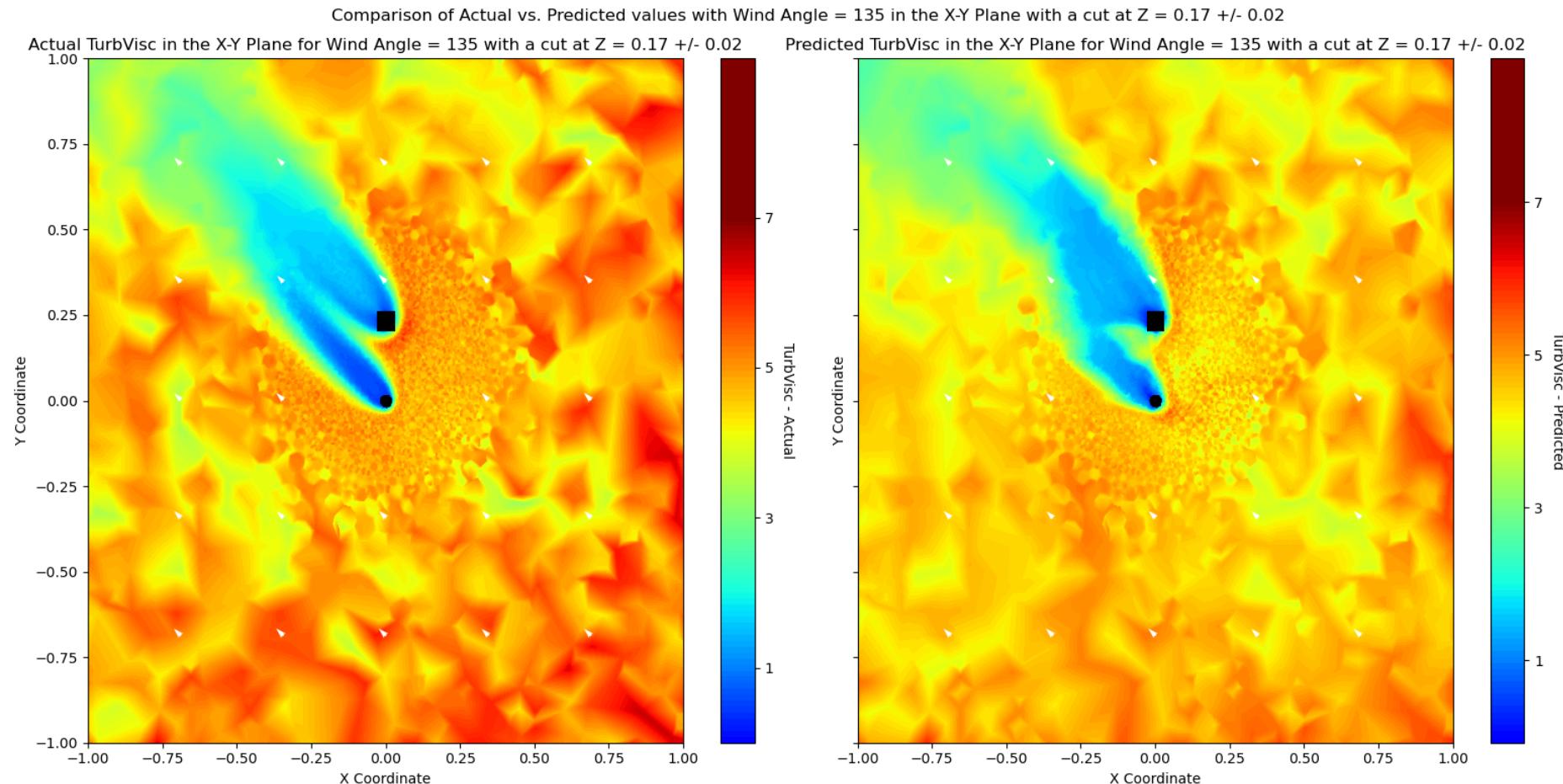
Progress so far - Data + Cont Loss (Adam Optimizer), Threshold = 1E-5 (4660 Epochs, so far...), Google Colab
Predicting Results - X-Y Total Velocity Plot (Angle = 135)



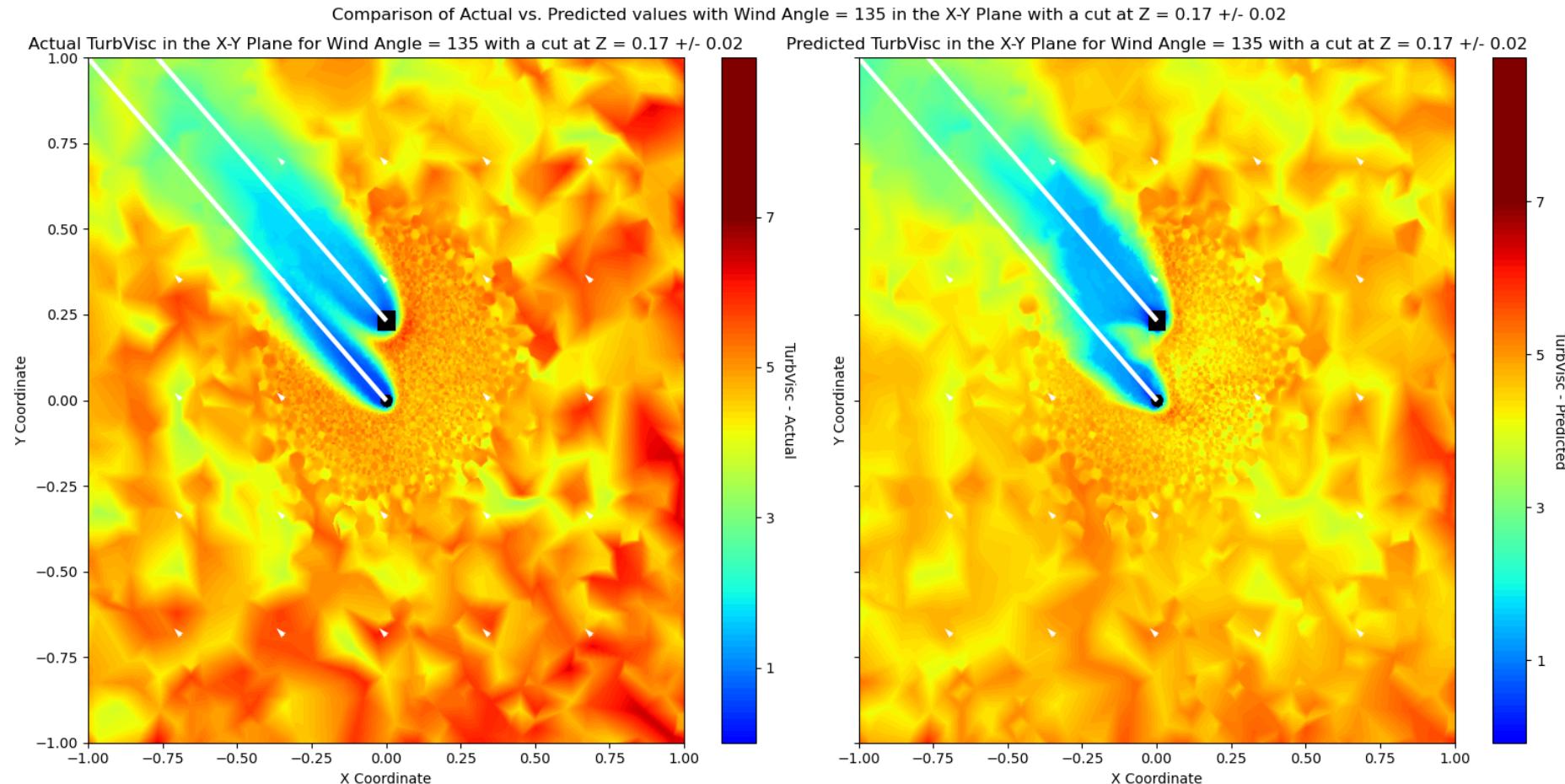
Progress so far - Data + Cont Loss (Adam Optimizer), Threshold = 1E-5 (4660 Epochs, so far...), Google Colab
Predicting Results - X-Y Total Velocity Plot (Angle = 135)



Progress so far - Data + Cont Loss (Adam Optimizer), Threshold = 1E-5 (4660 Epochs, so far...), Google Colab
Predicting Results - X-Y TurbVisc Plot (Angle = 135)



Progress so far - Data + Cont Loss (Adam Optimizer), Threshold = 1E-5 (4660 Epochs, so far...), Google Colab
Predicting Results - X-Y TurbVisc Plot (Angle = 135)

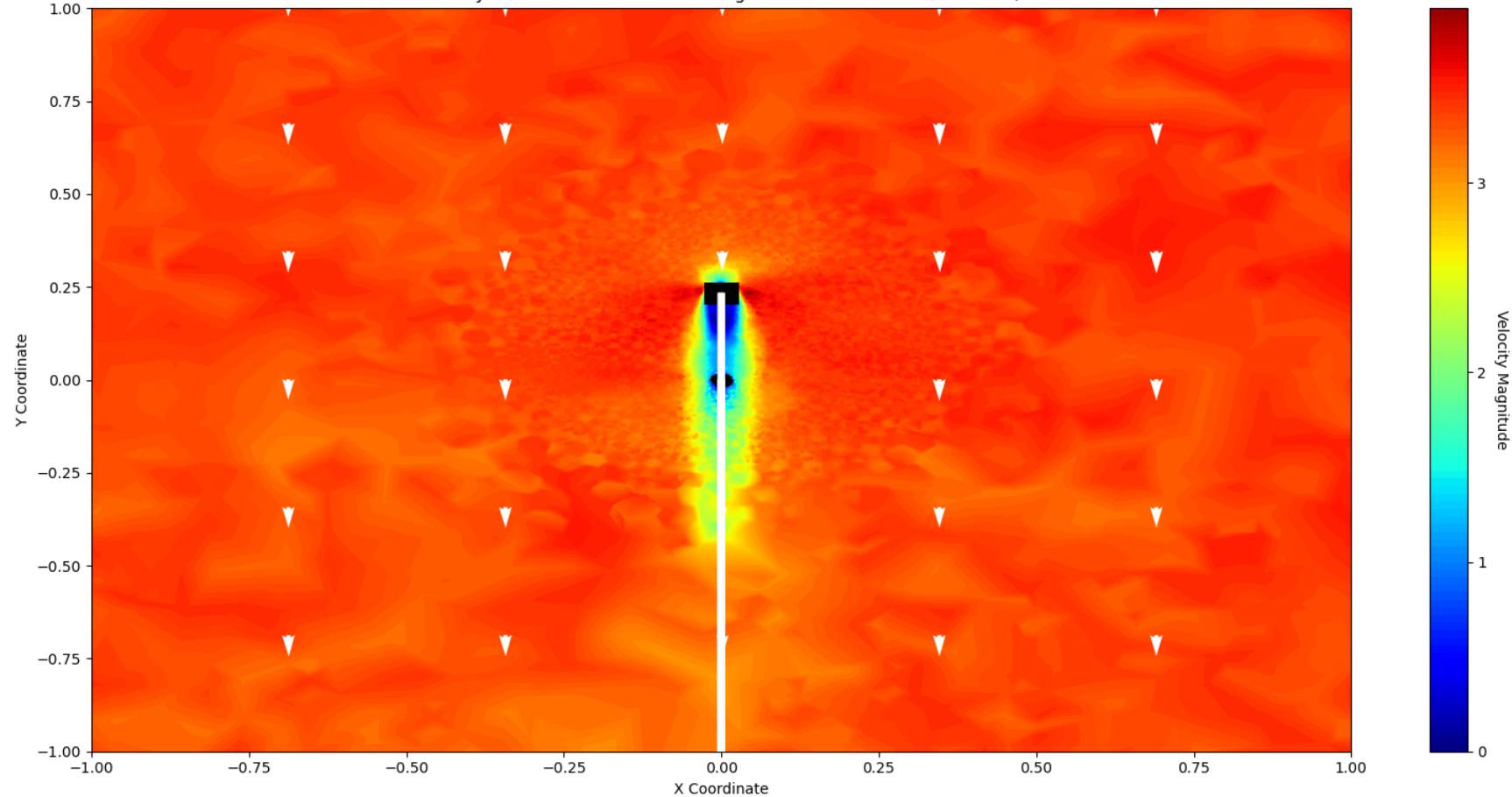


Progress so far - Data Loss + Cont Loss
(WITHOUT Boundary Conditions imposed)
(Adam Optimizer)

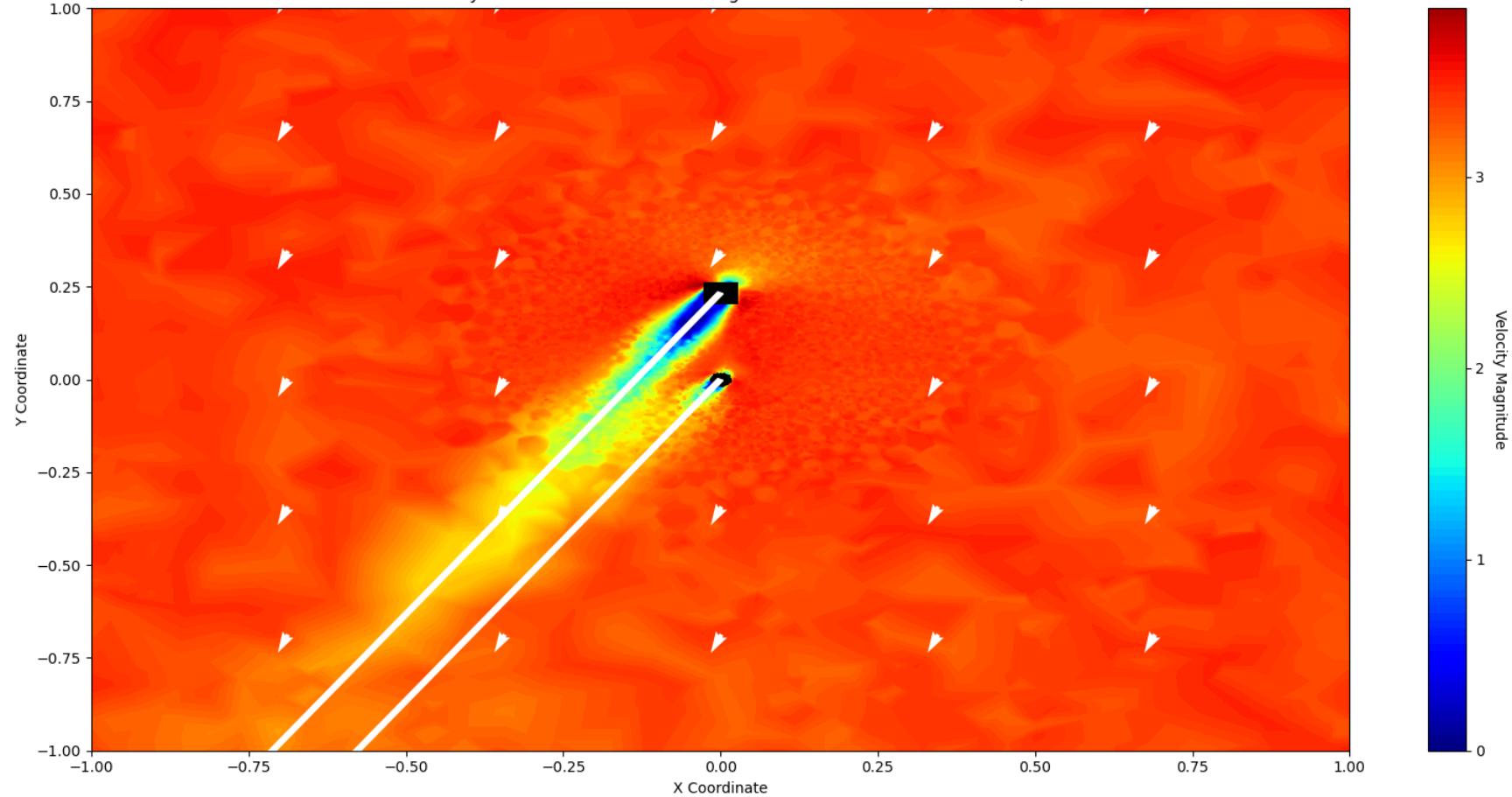
Threshold = 1E-5 (4660 Epochs, not completed), Google Colab

Scripts v3 – Plotting Any Angle

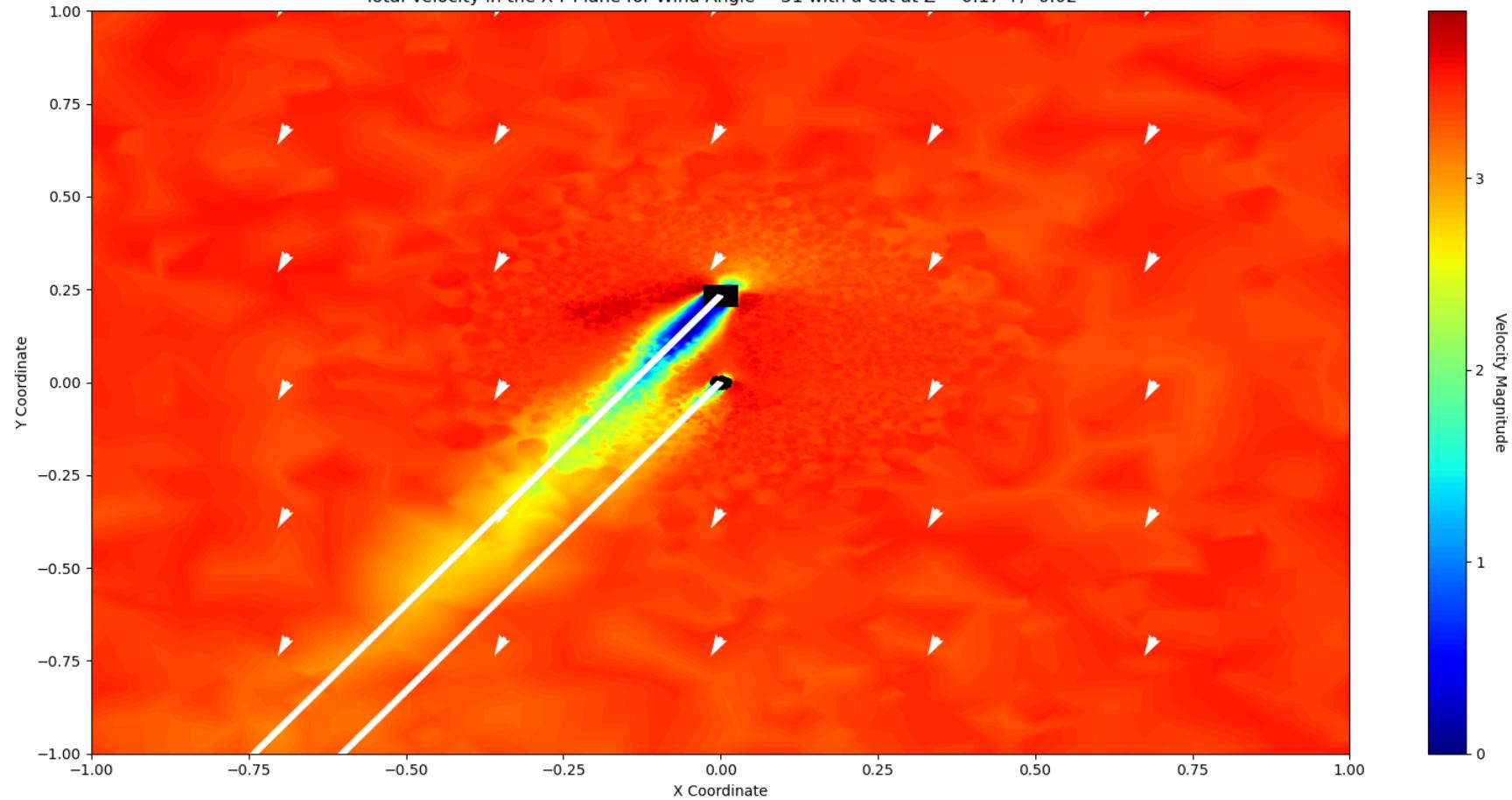
Total Velocity in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



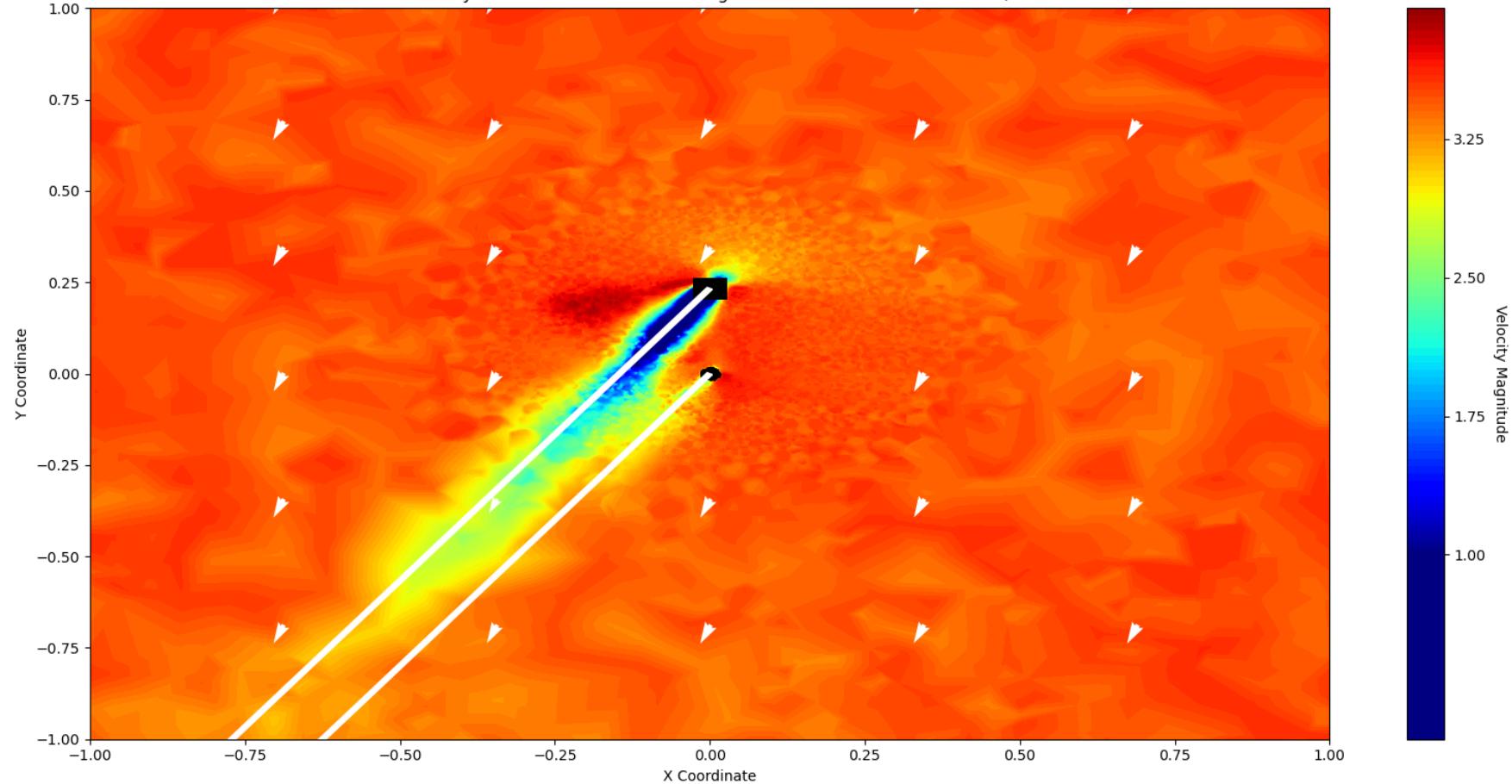
Total Velocity in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



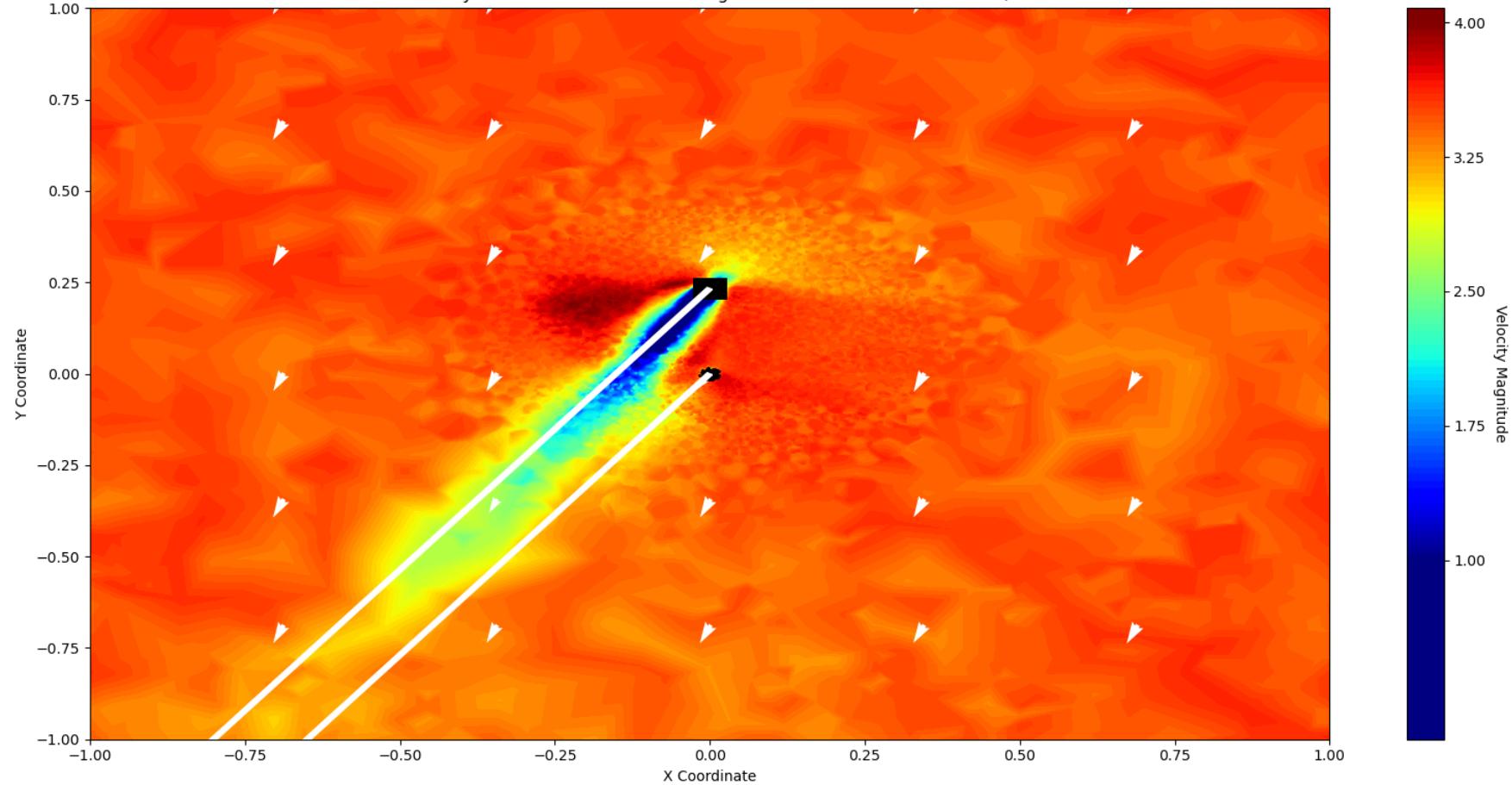
Total Velocity in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



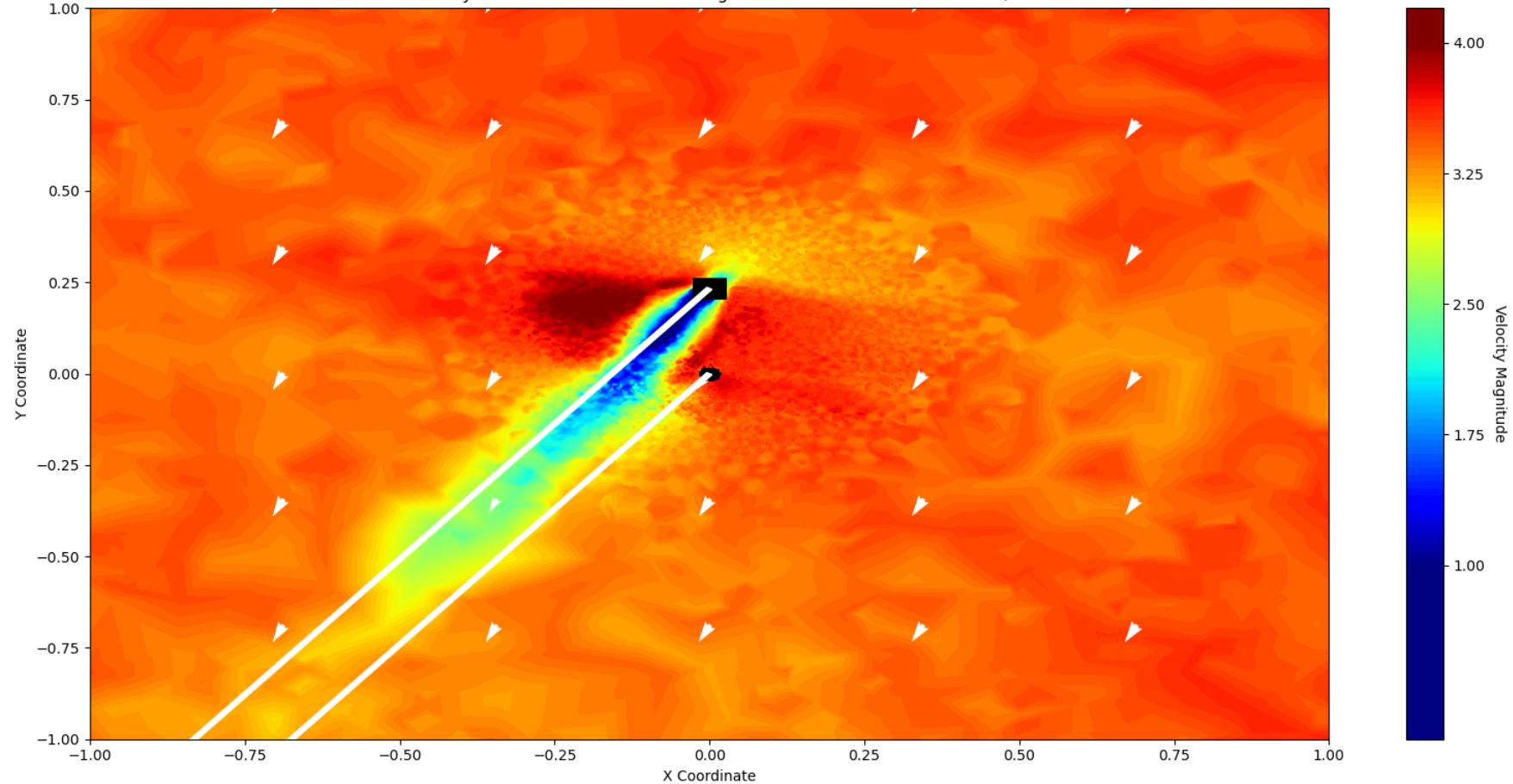
Total Velocity in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



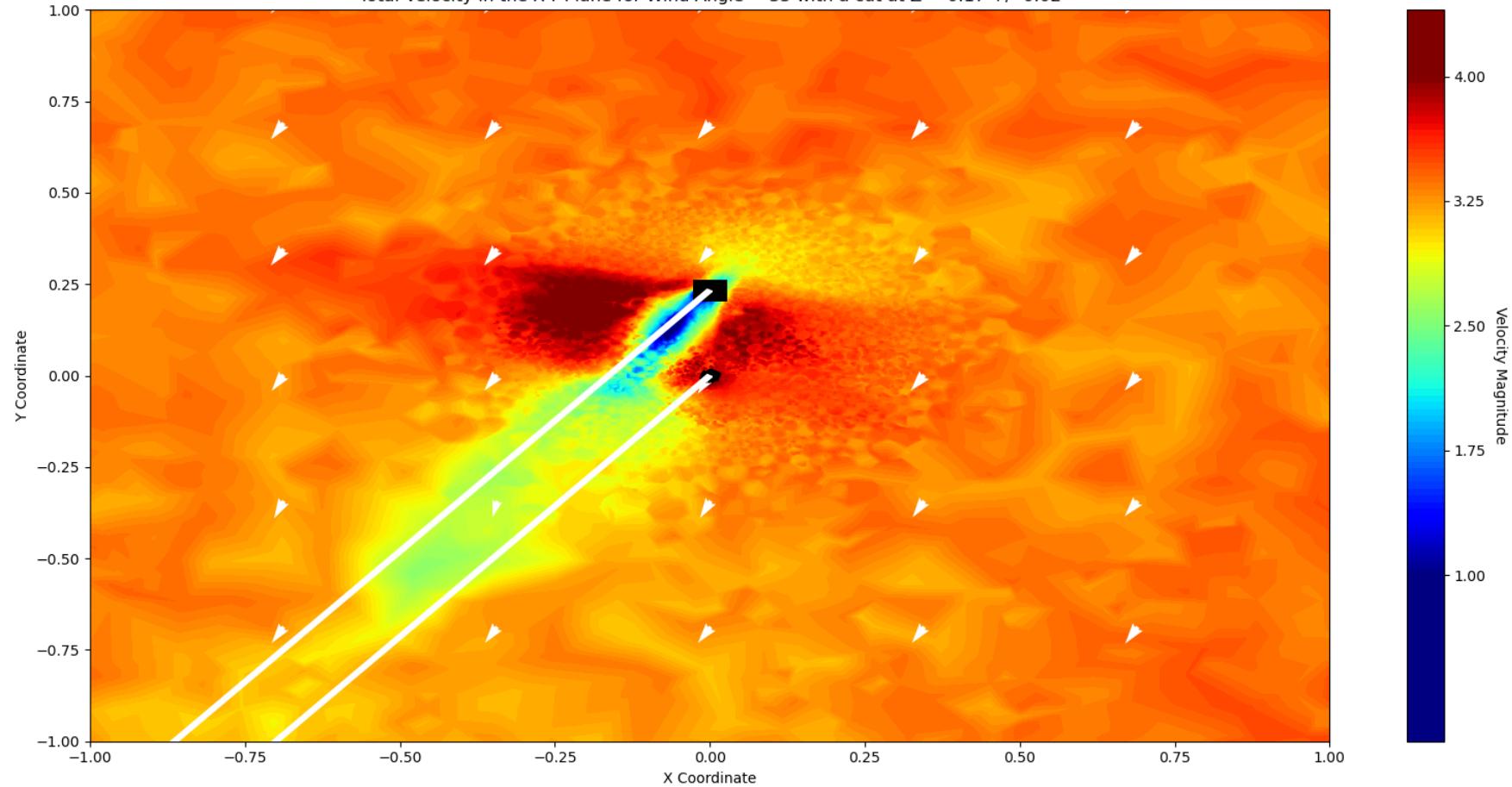
Total Velocity in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



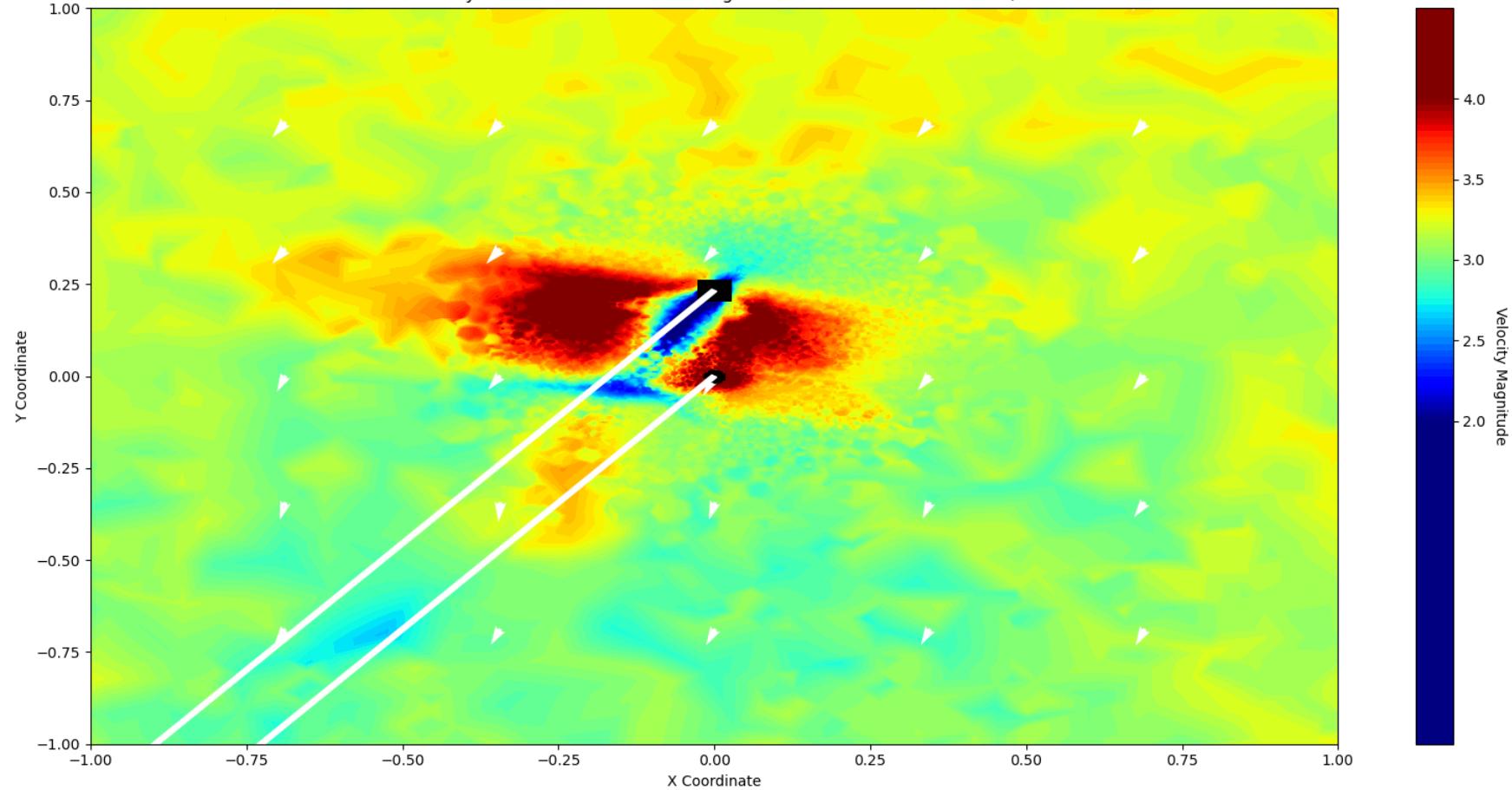
Total Velocity in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



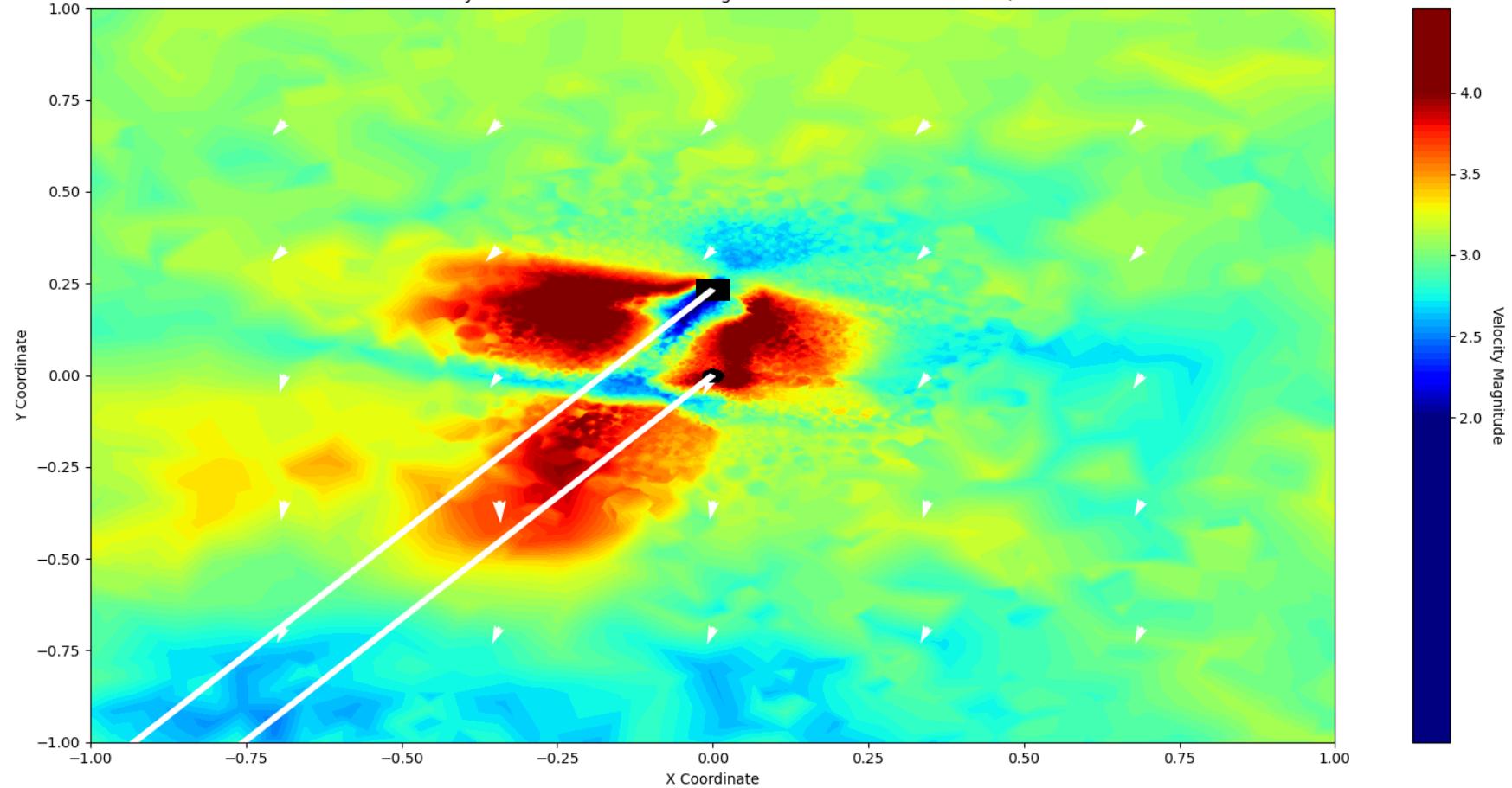
Total Velocity in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



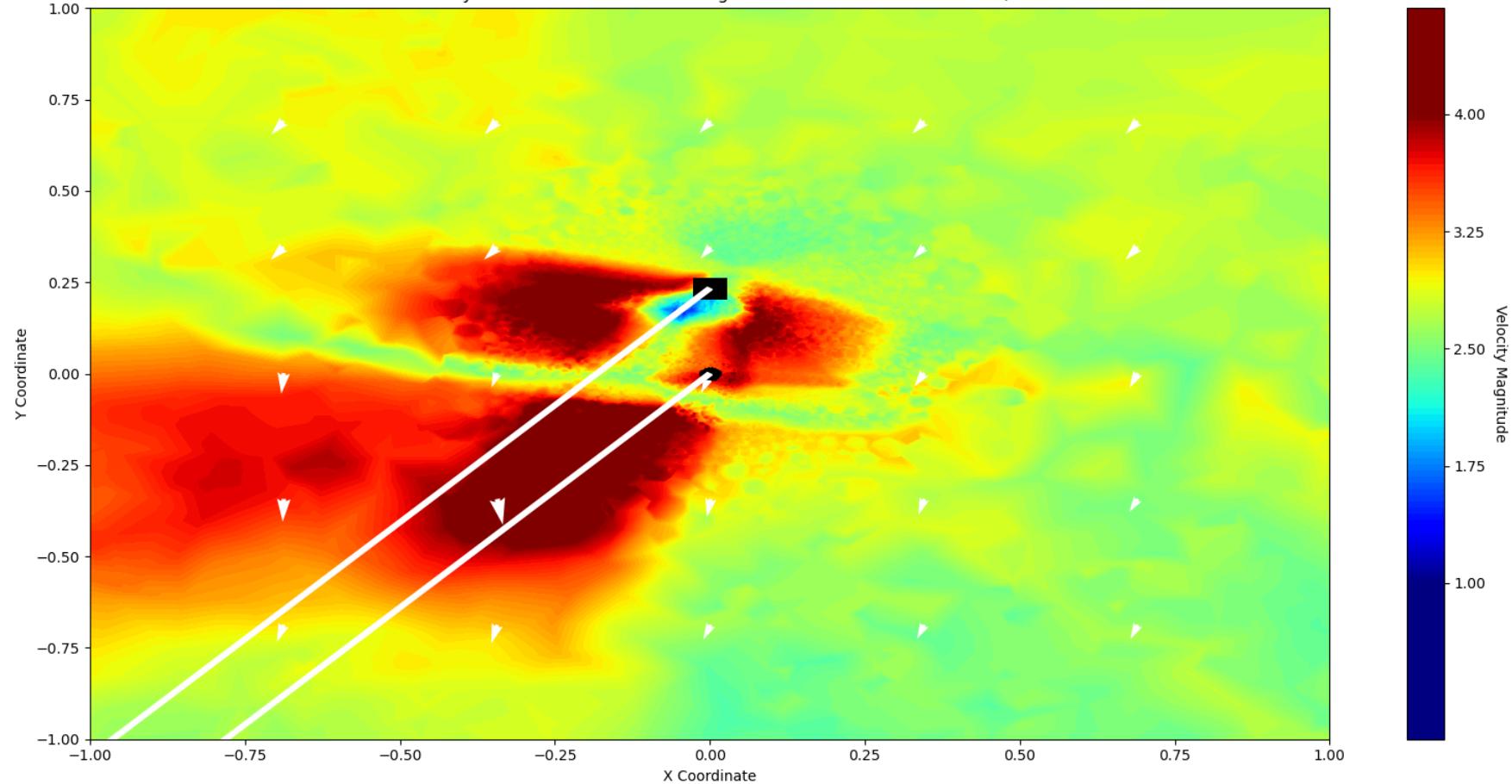
Total Velocity in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



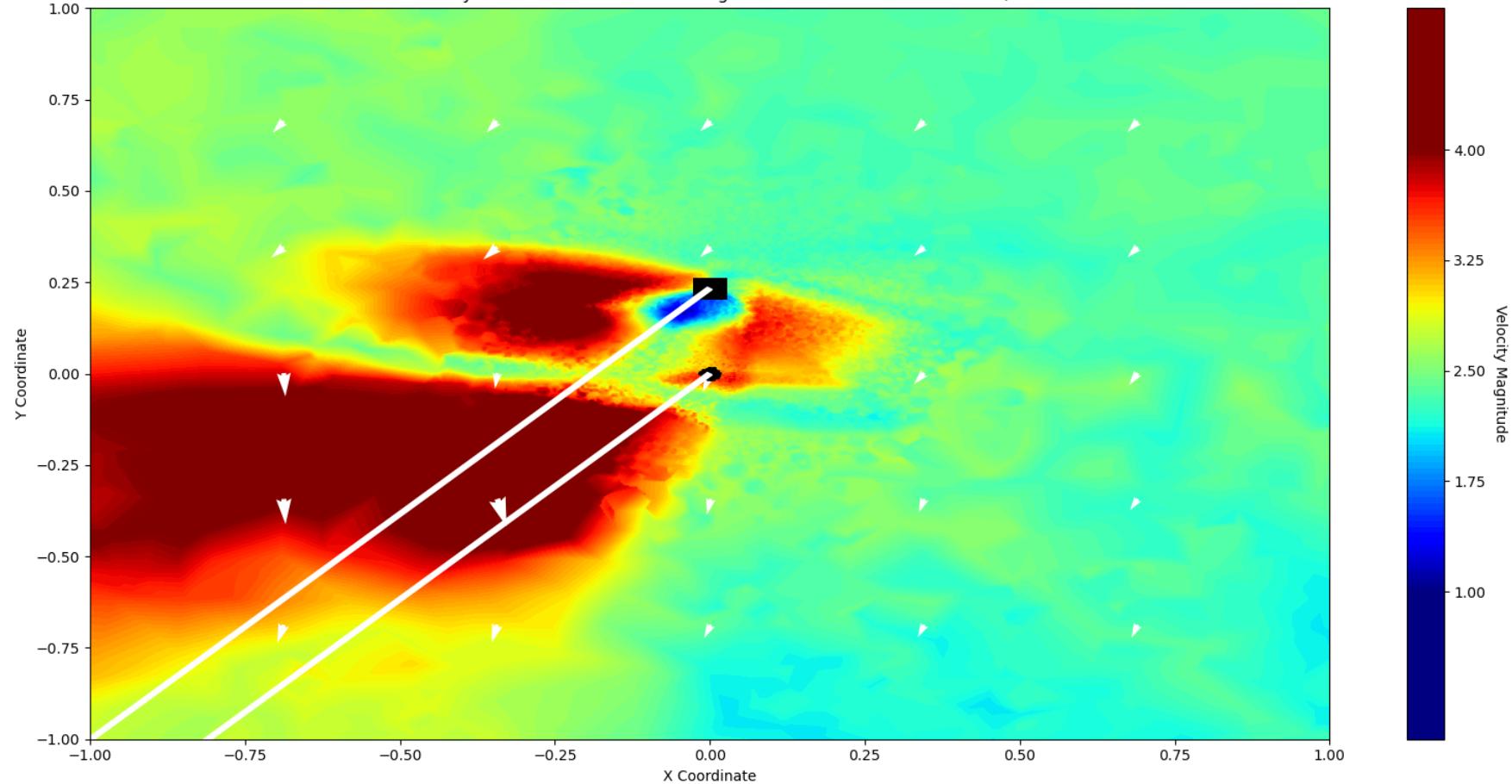
Total Velocity in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



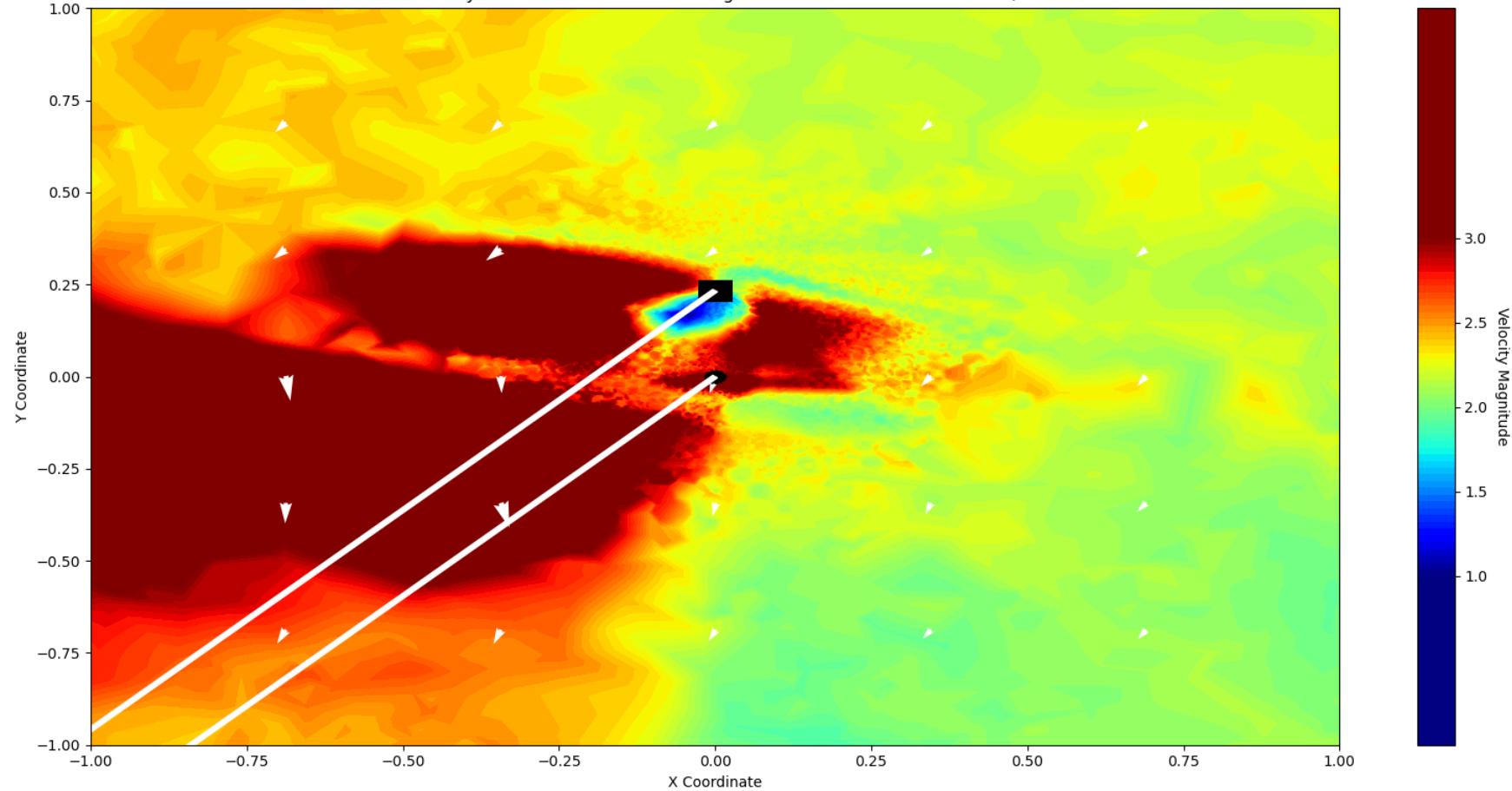
Total Velocity in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



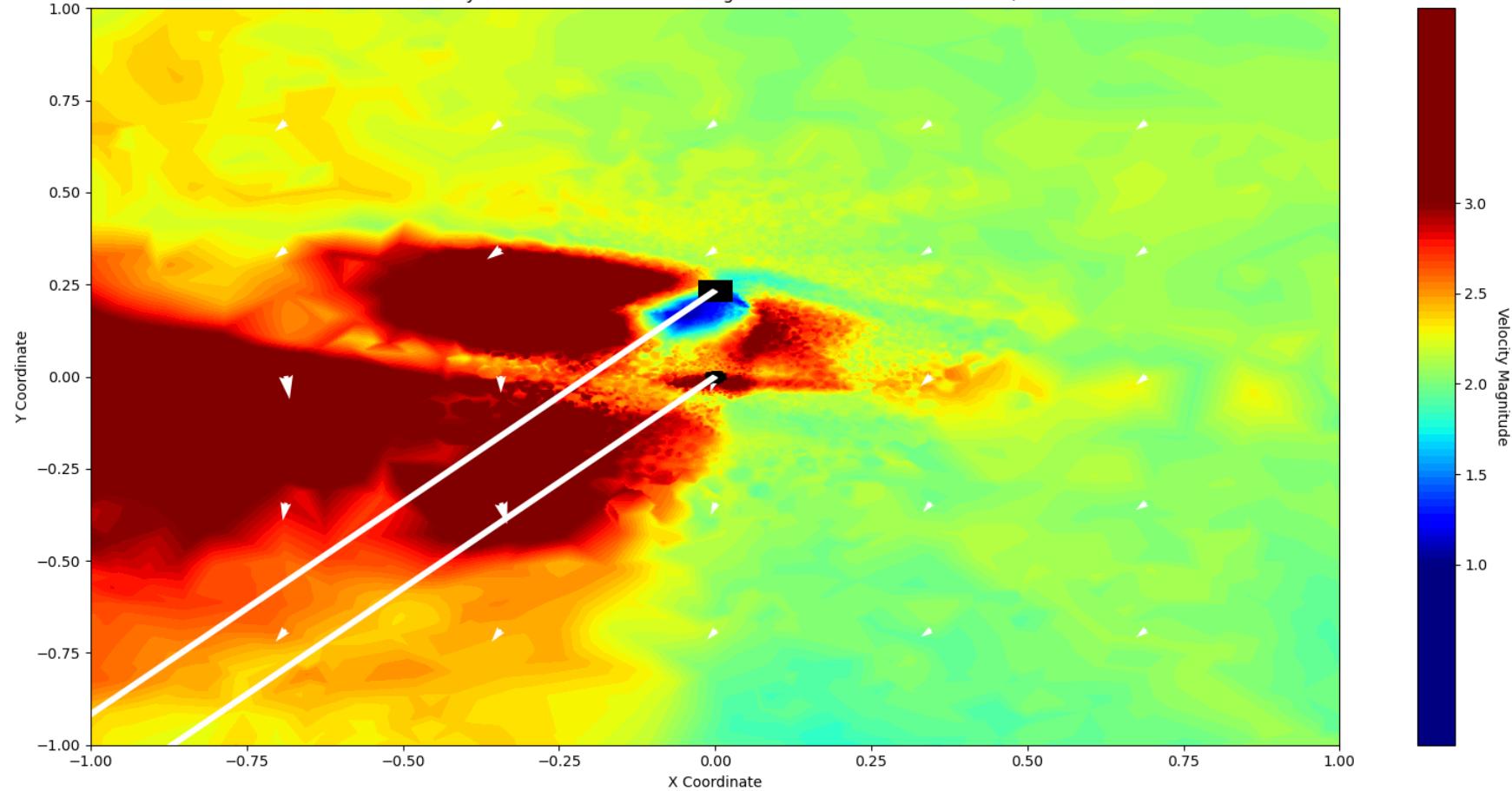
Total Velocity in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



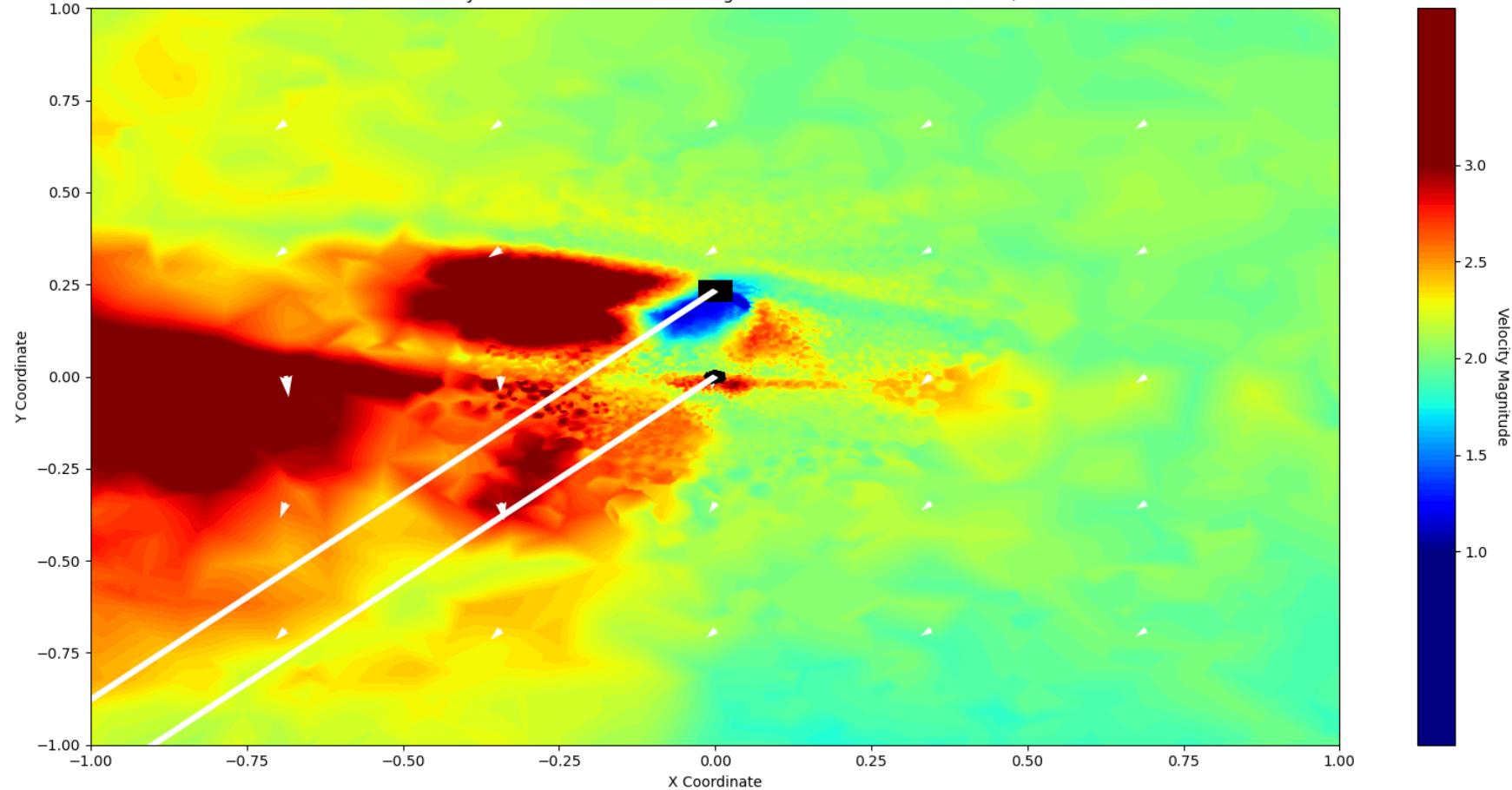
Total Velocity in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



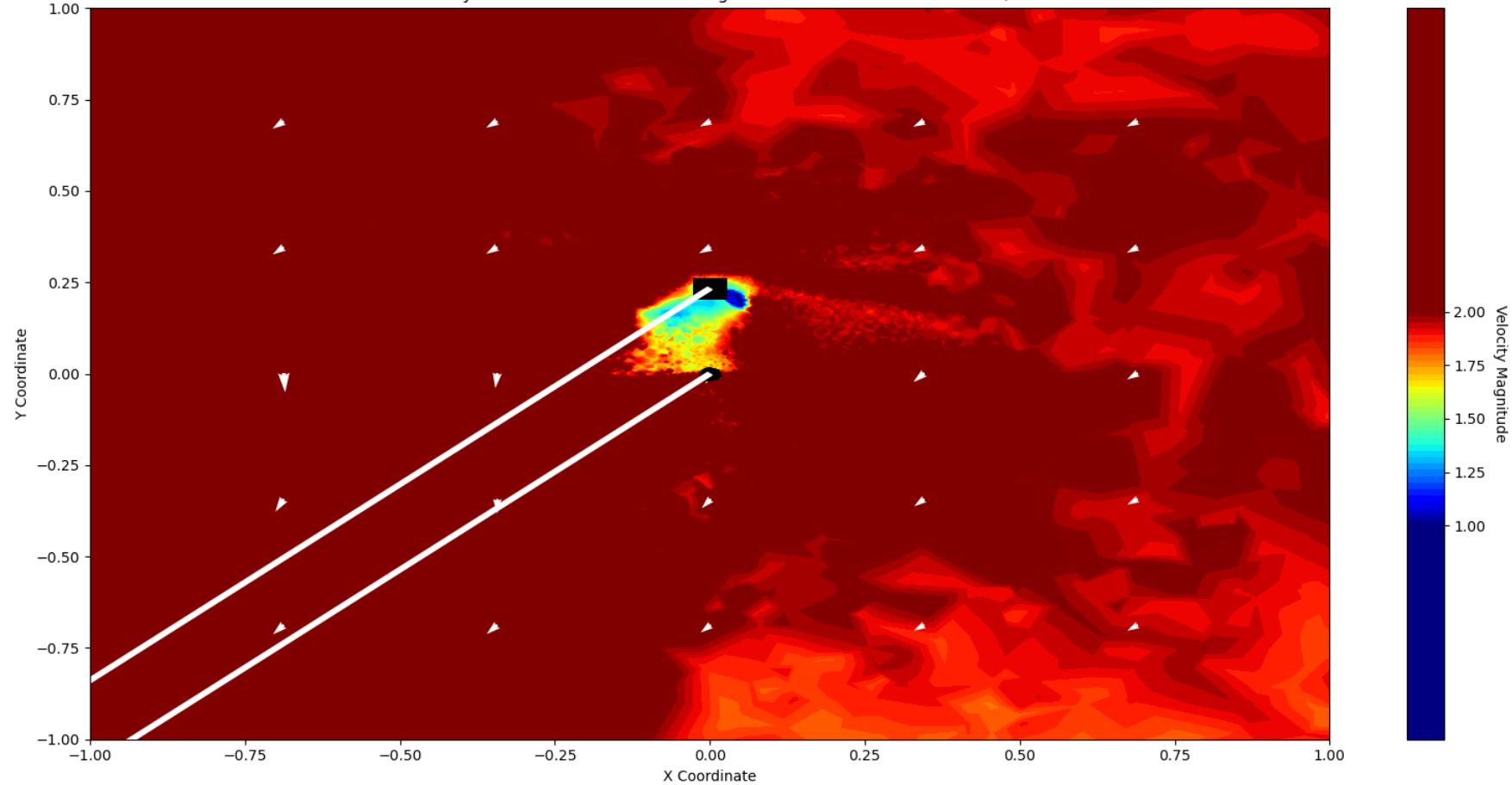
Total Velocity in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



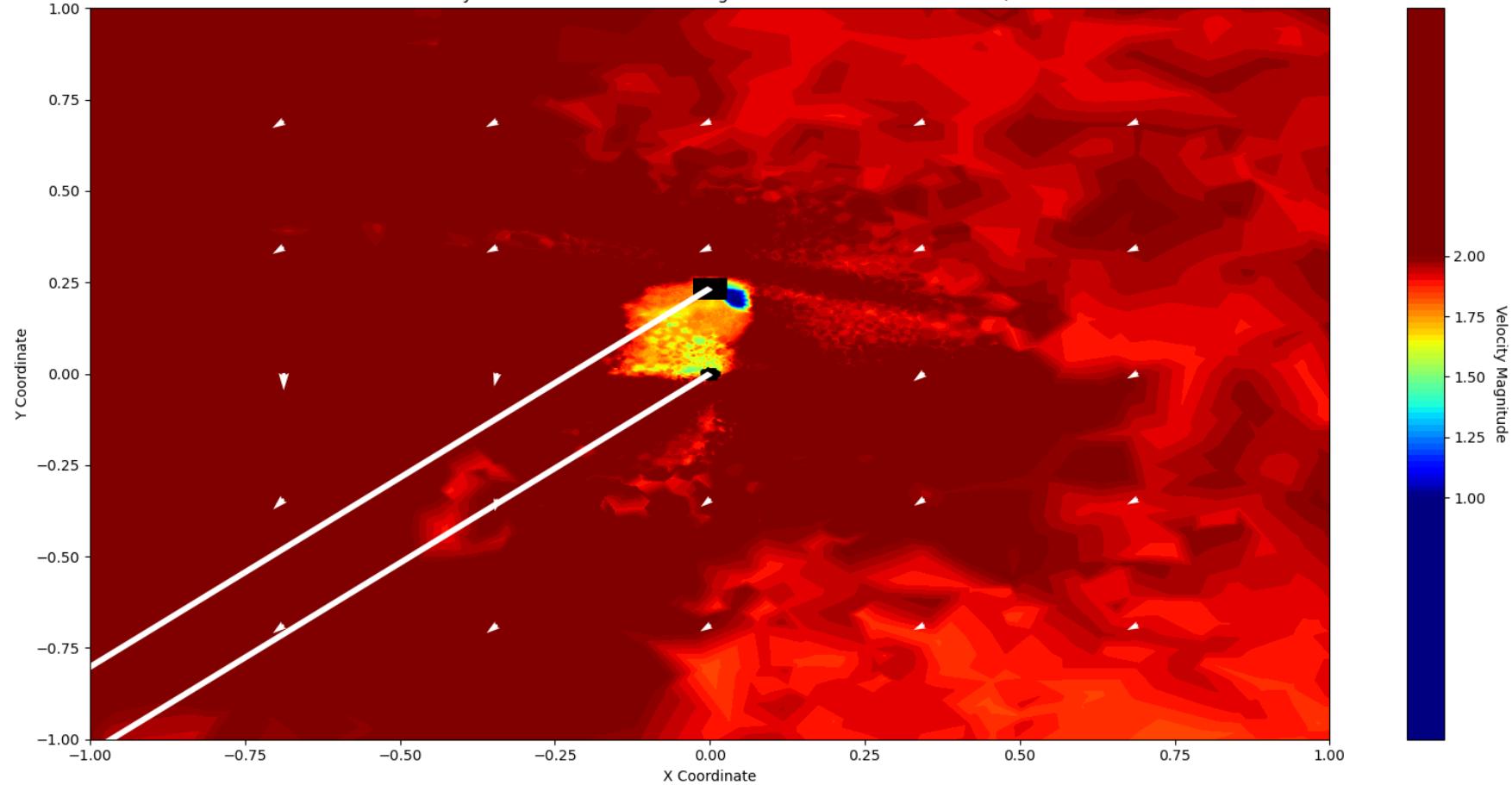
Total Velocity in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



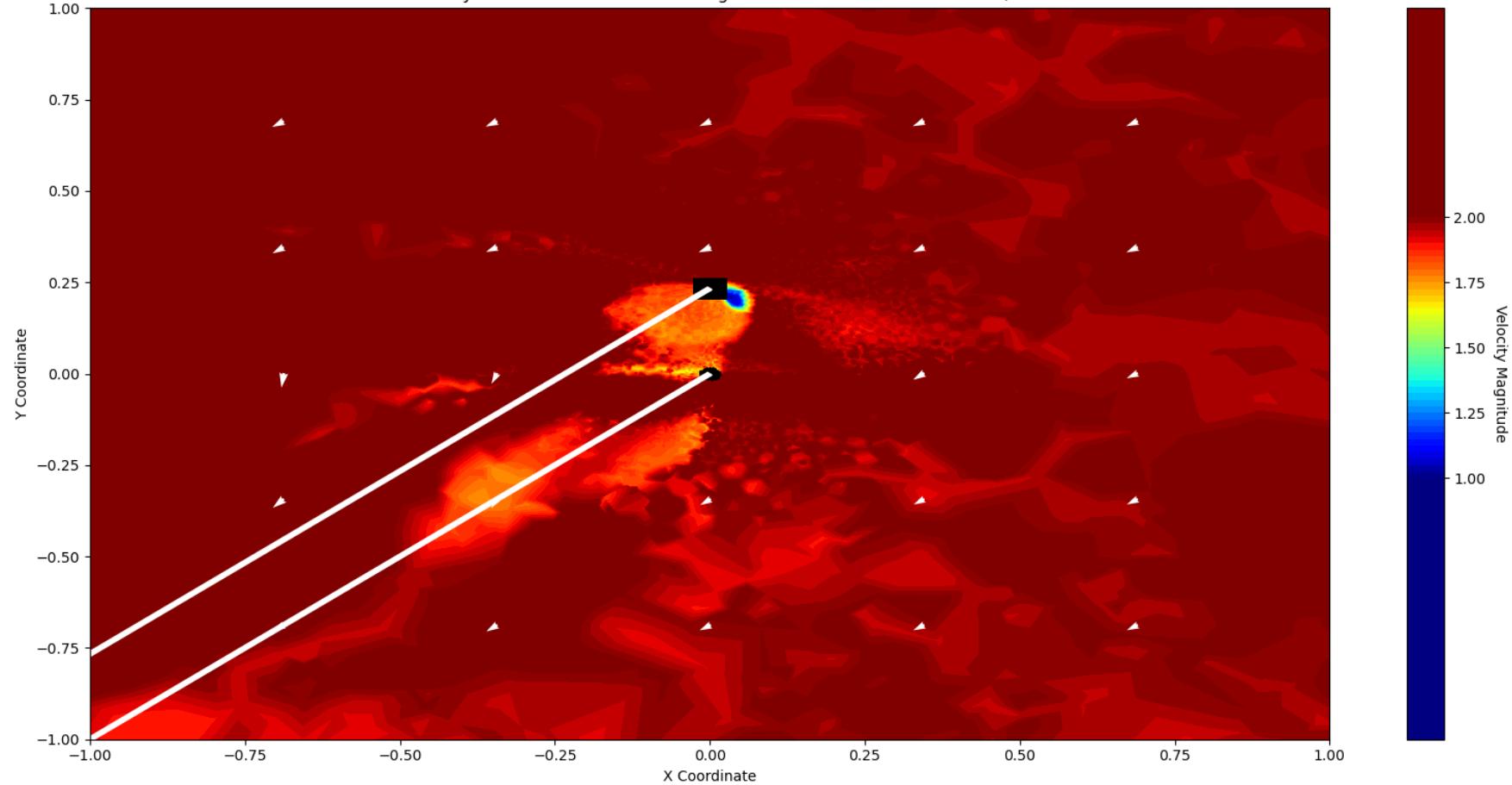
Total Velocity in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



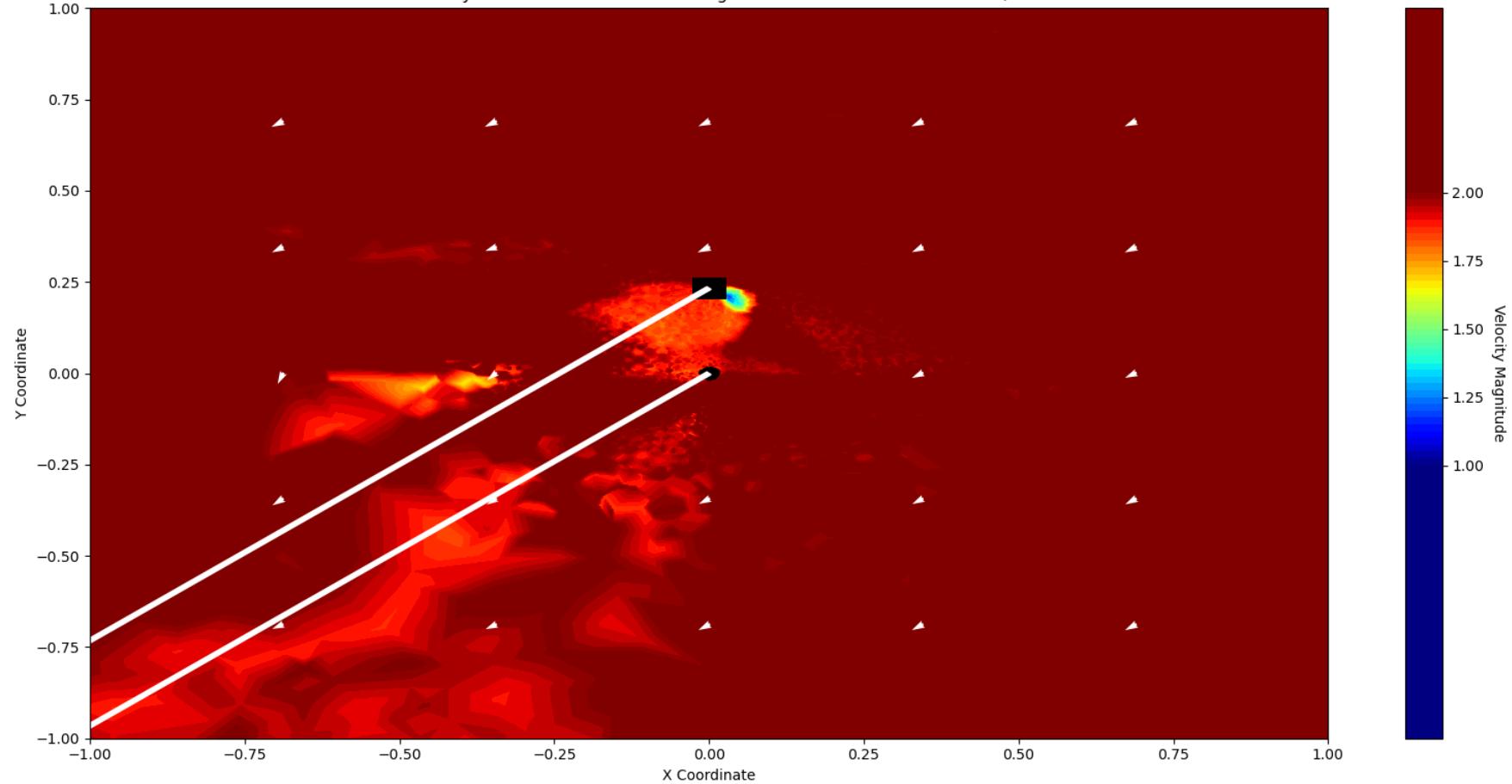
Total Velocity in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



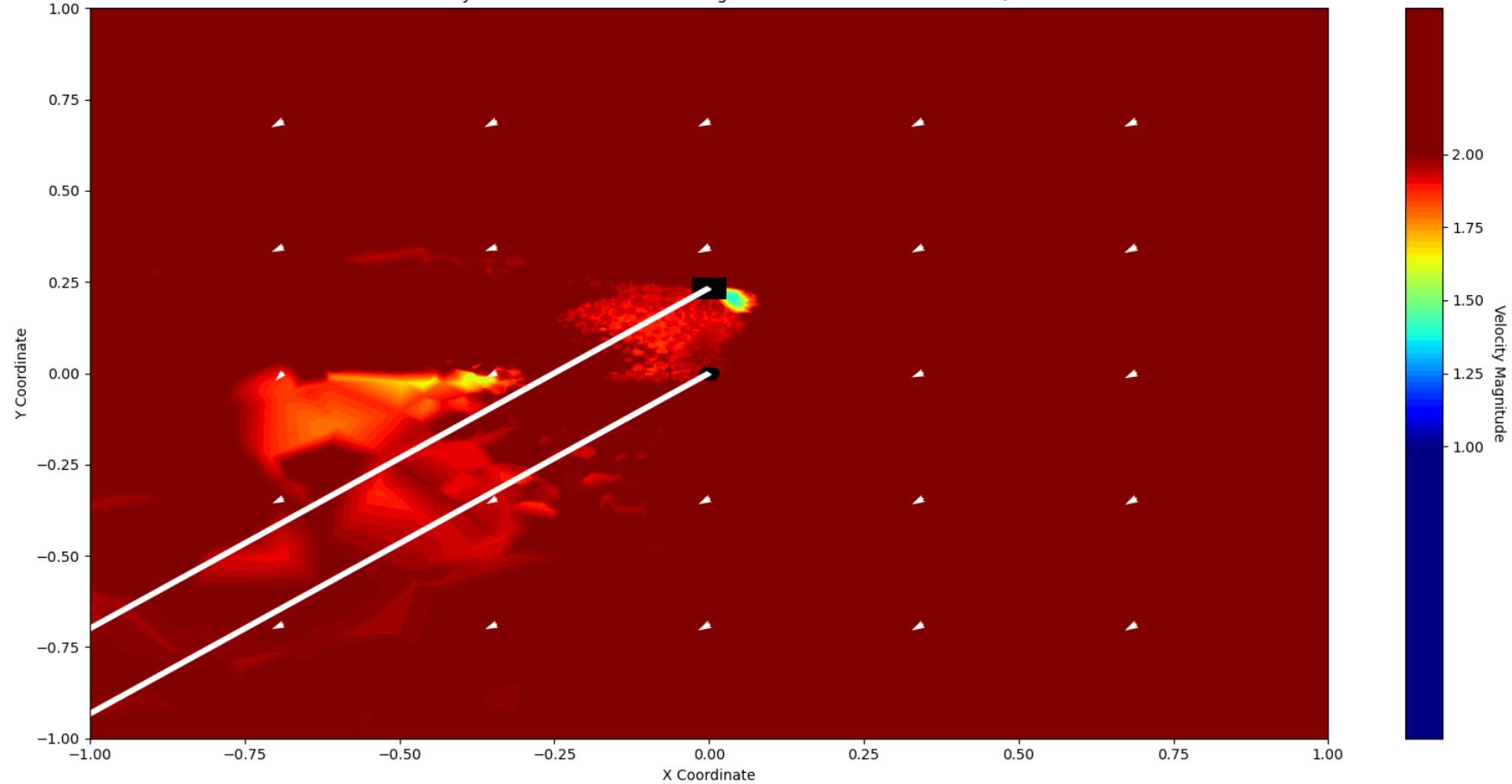
Total Velocity in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



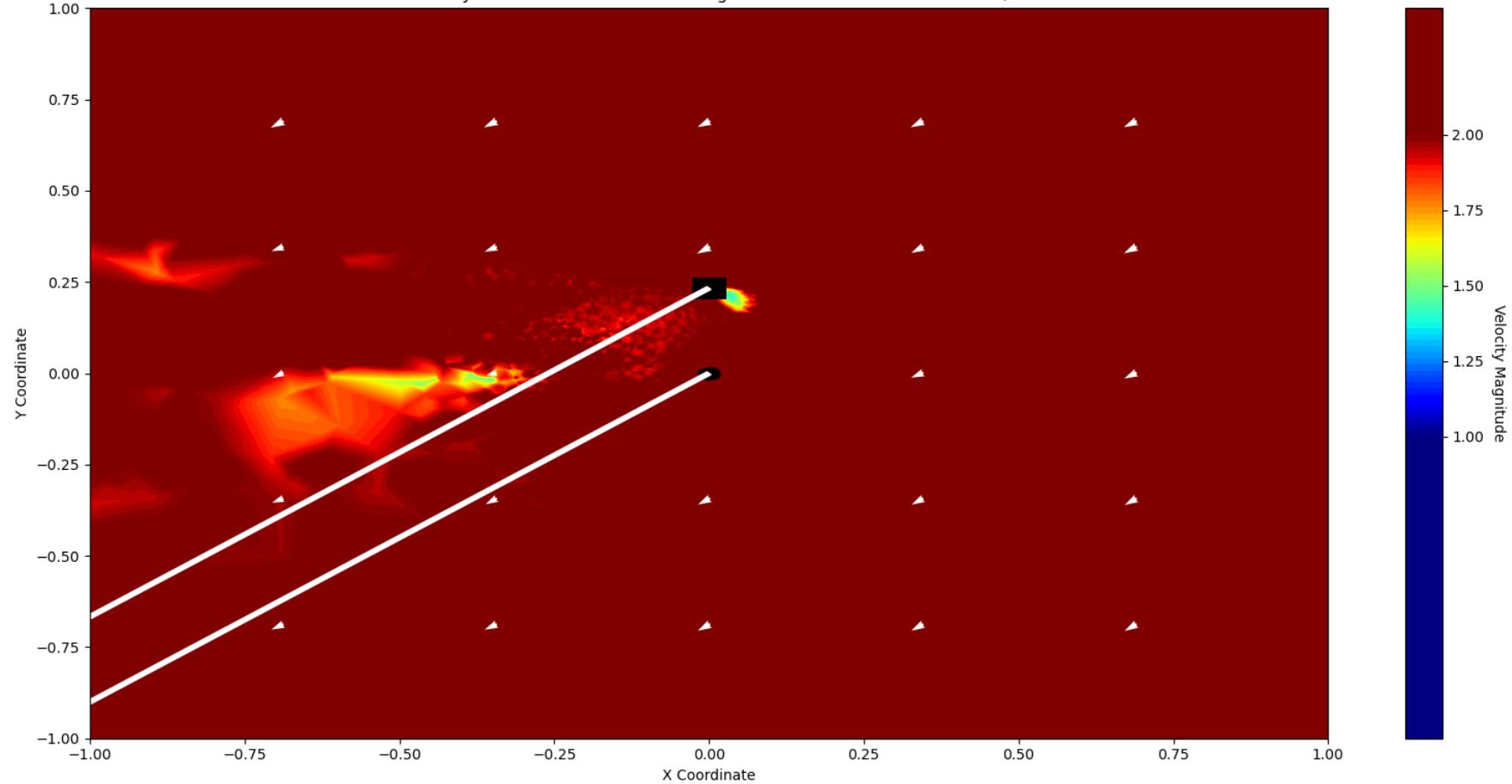
Total Velocity in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



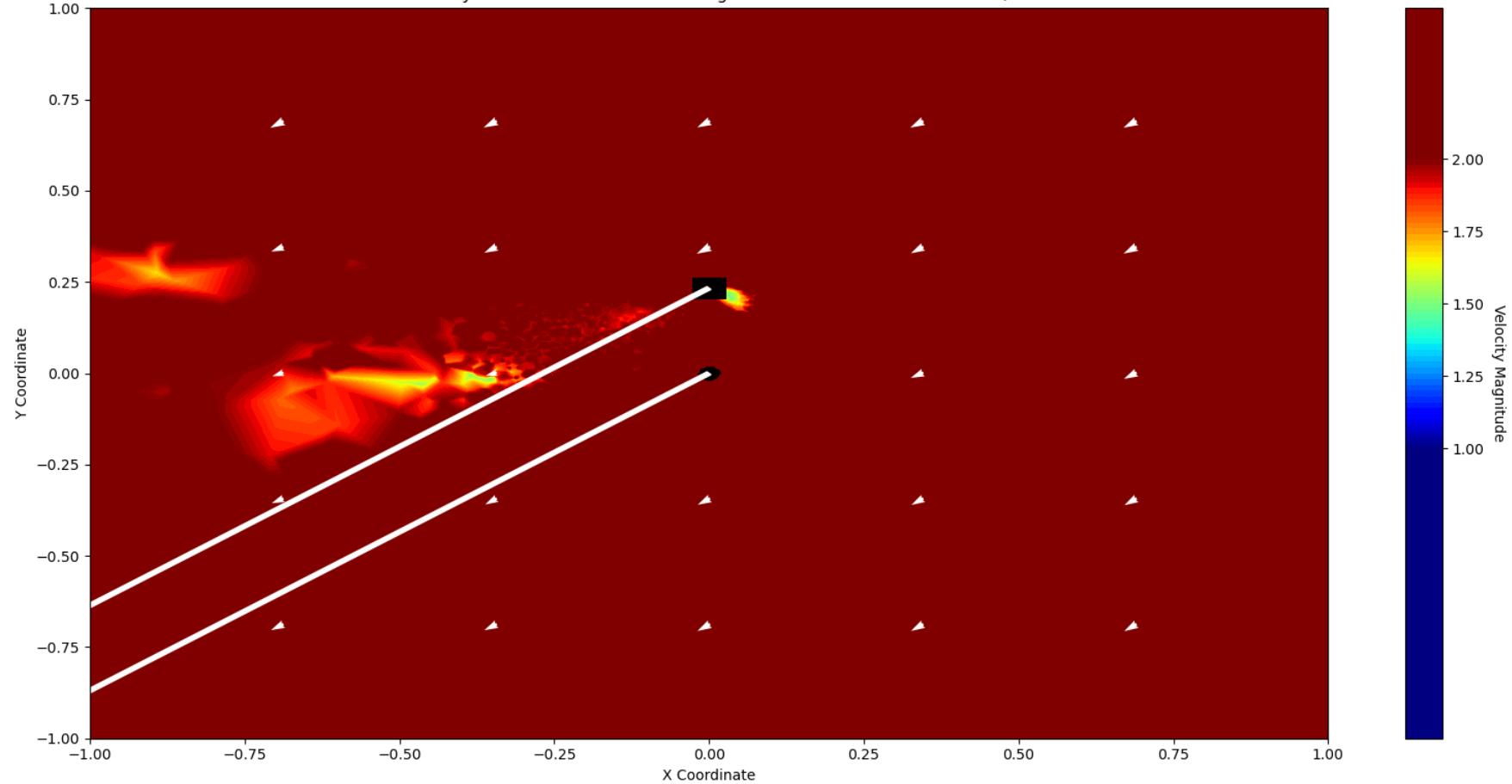
Total Velocity in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



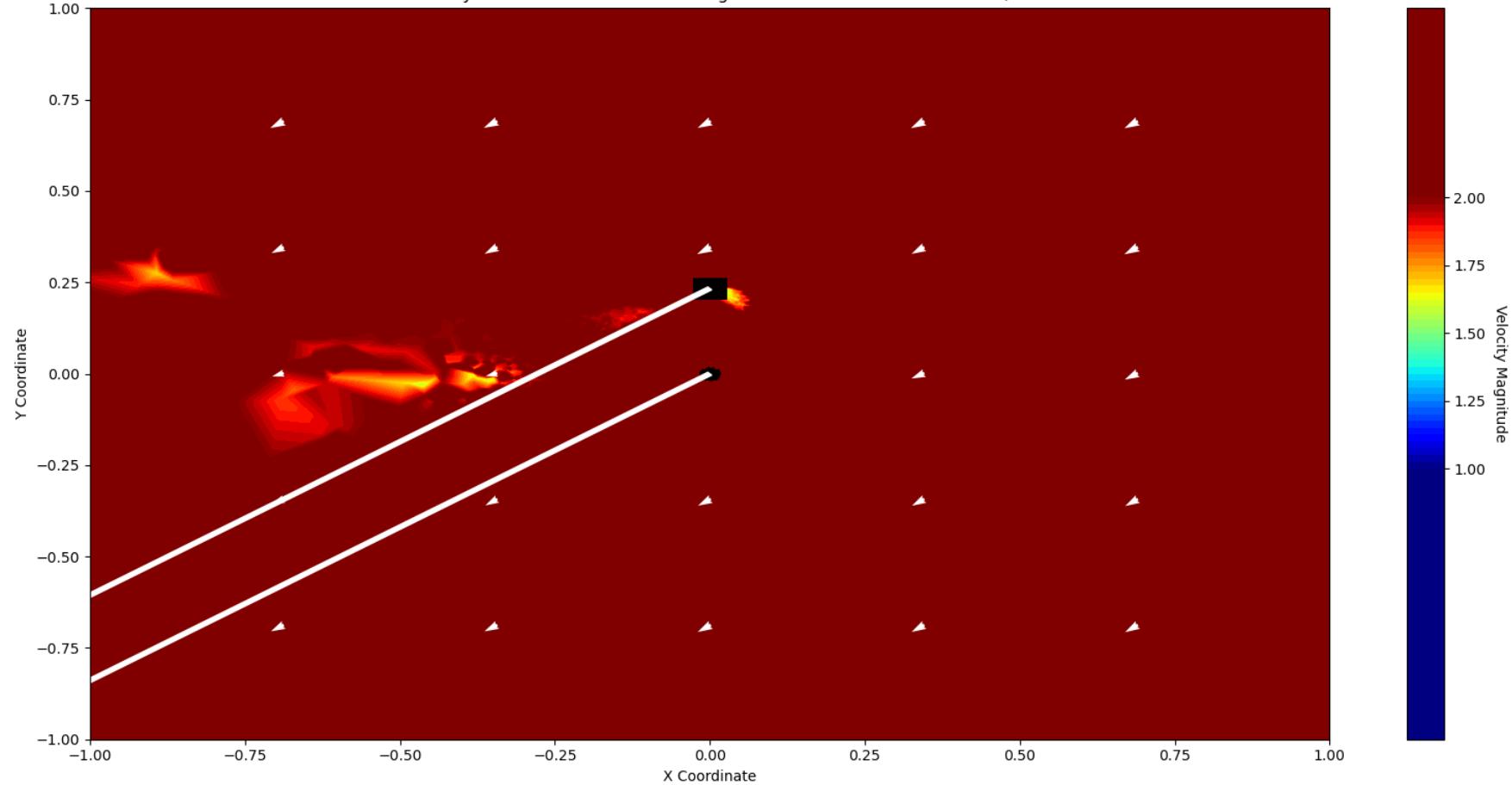
Total Velocity in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



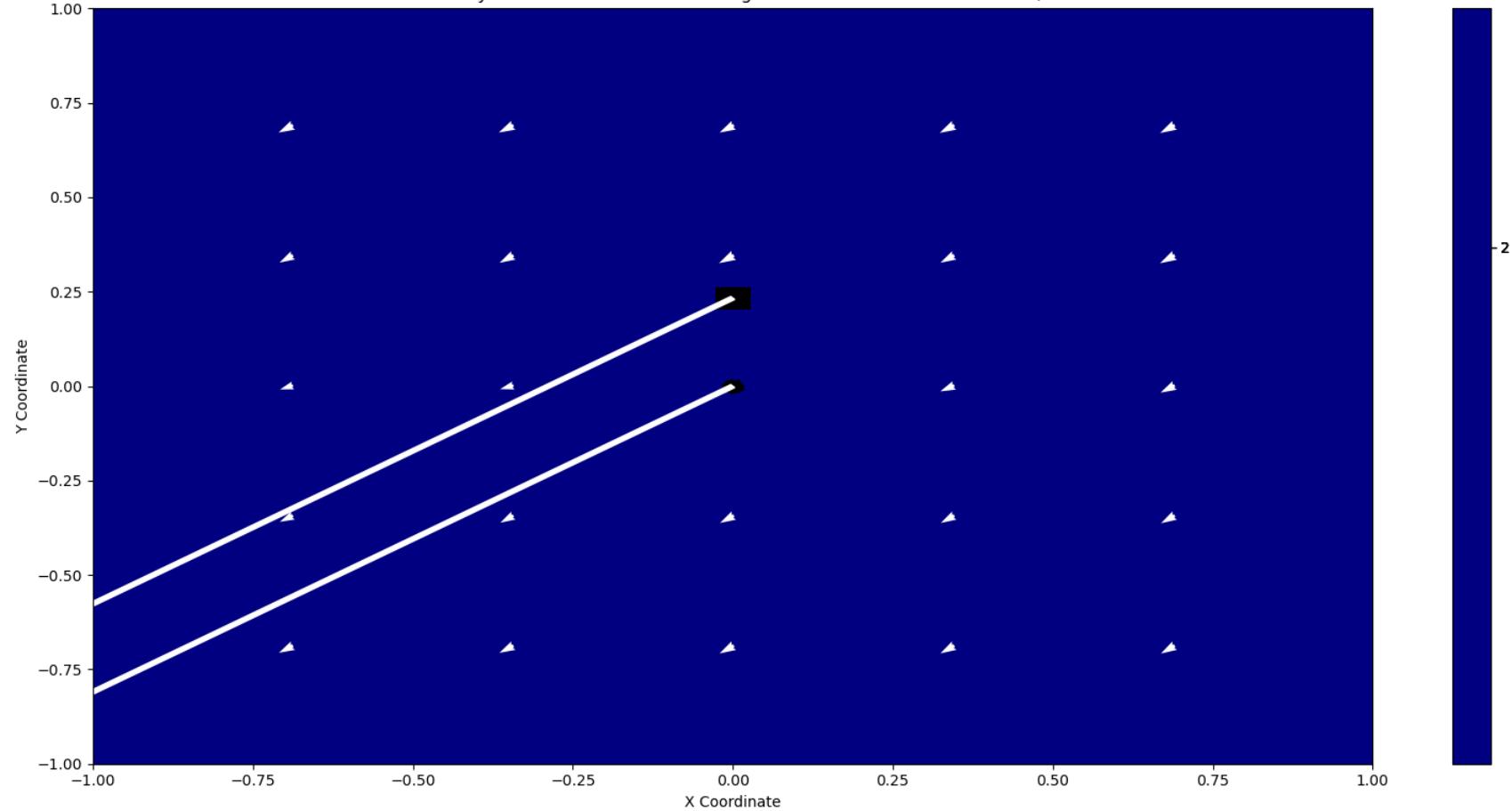
Total Velocity in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



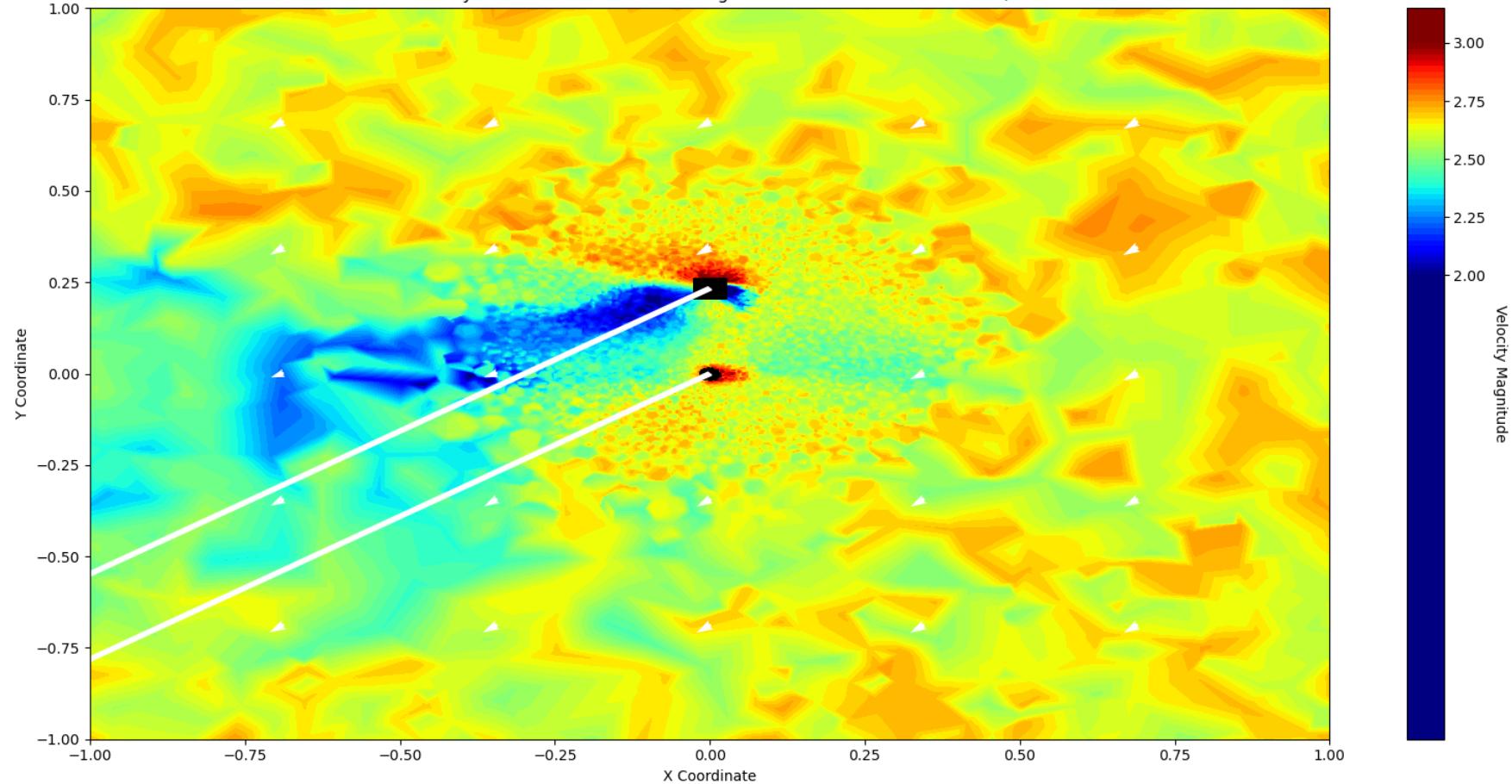
Total Velocity in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



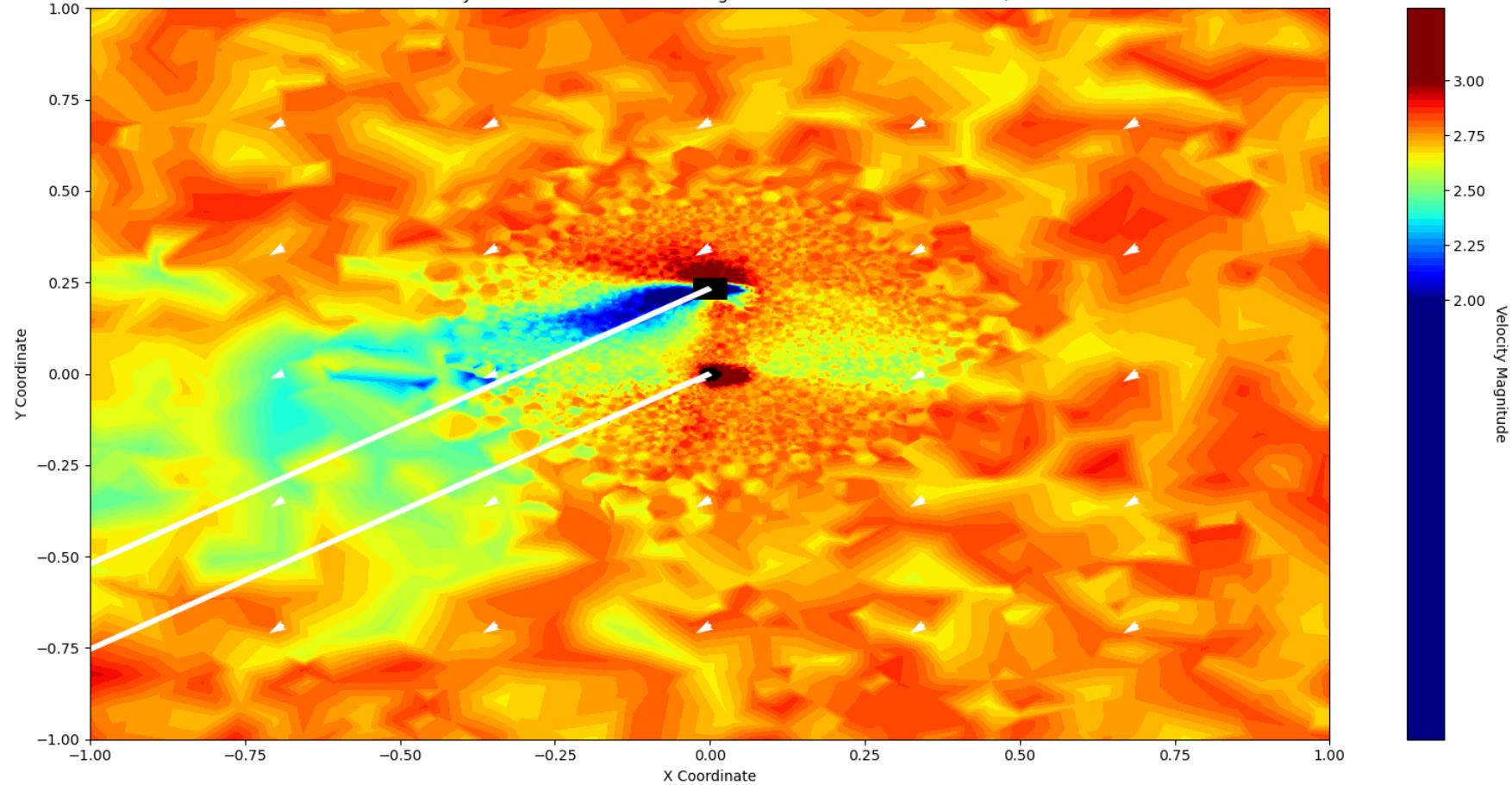
Total Velocity in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



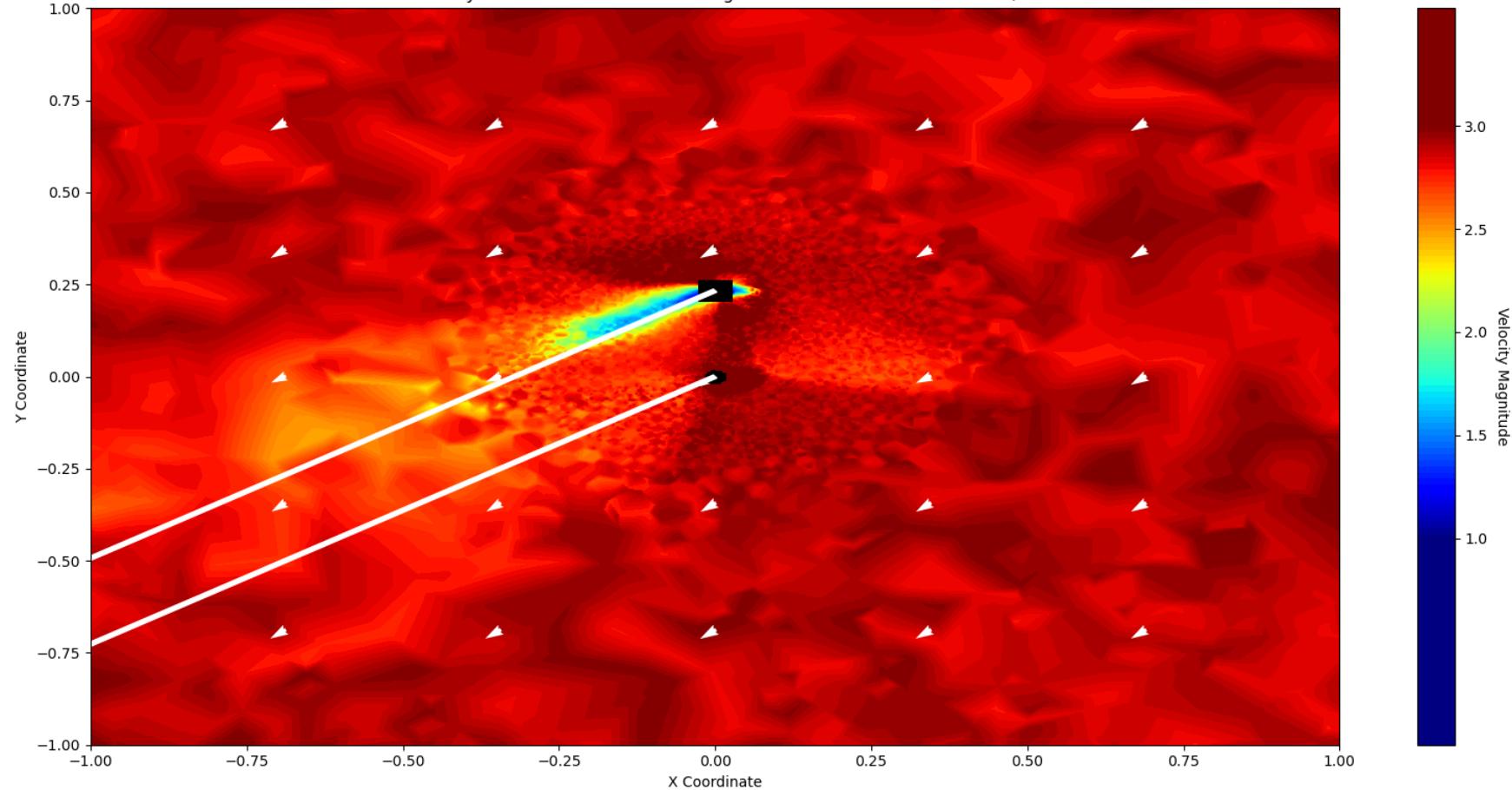
Total Velocity in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



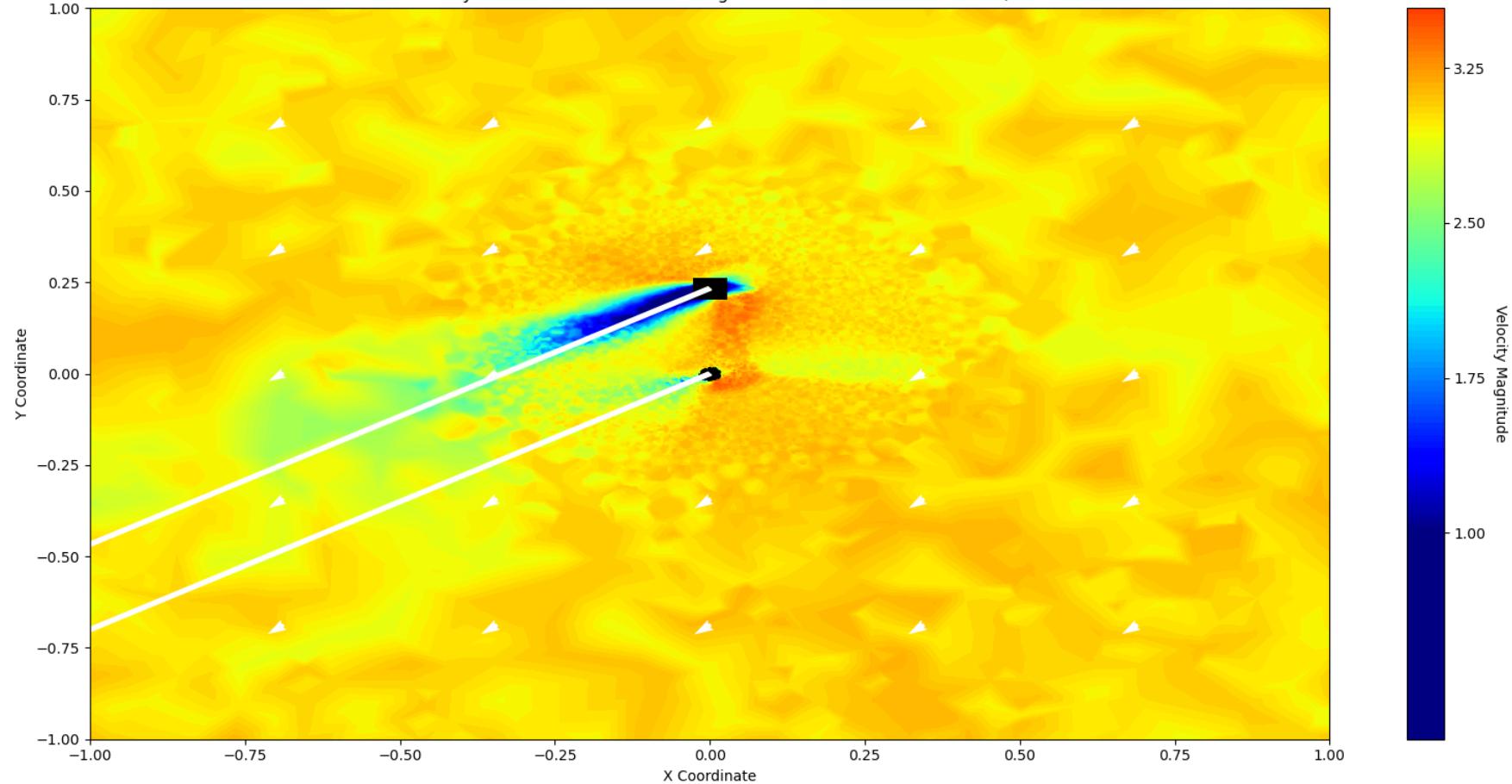
Total Velocity in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



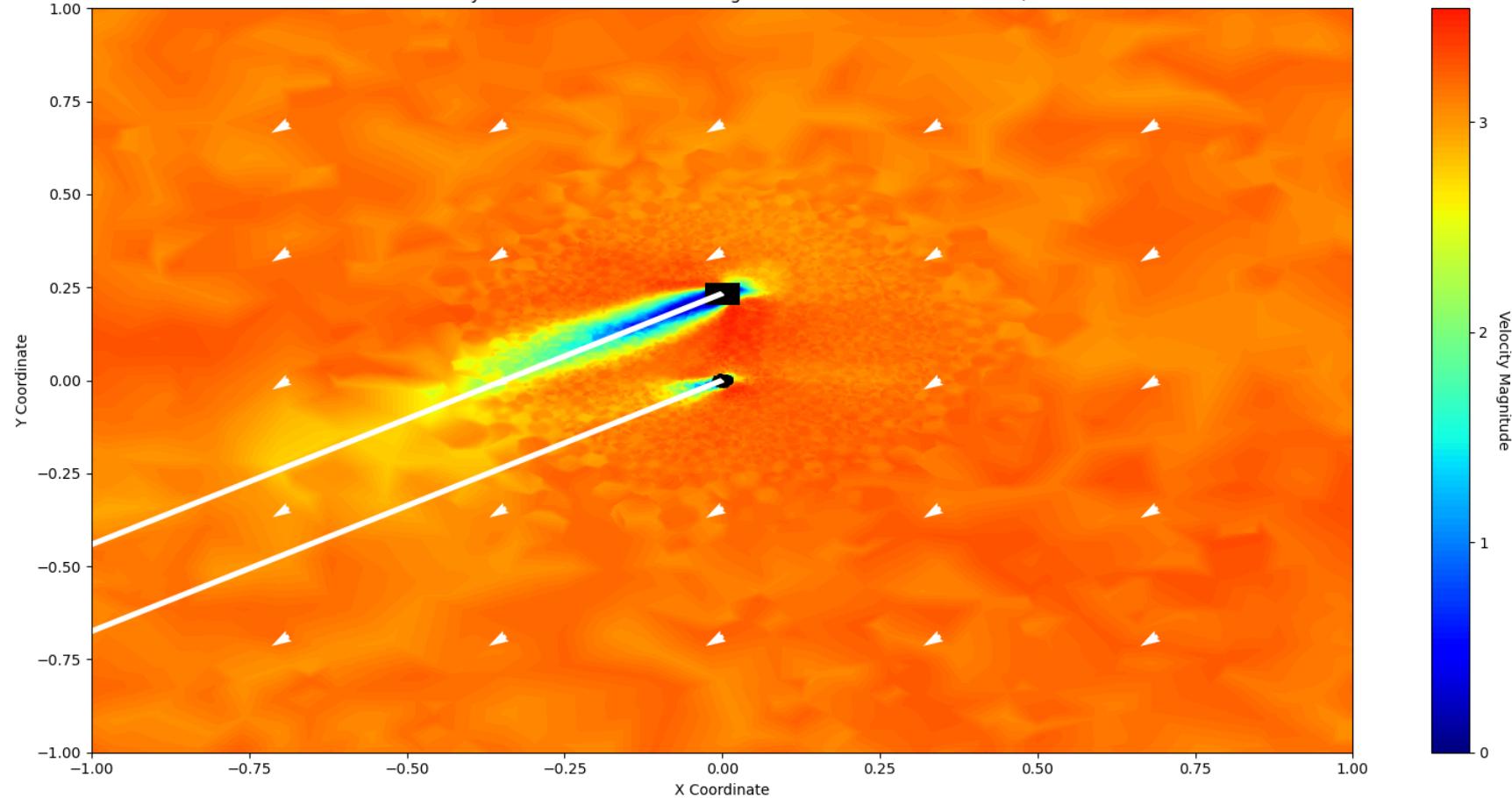
Total Velocity in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



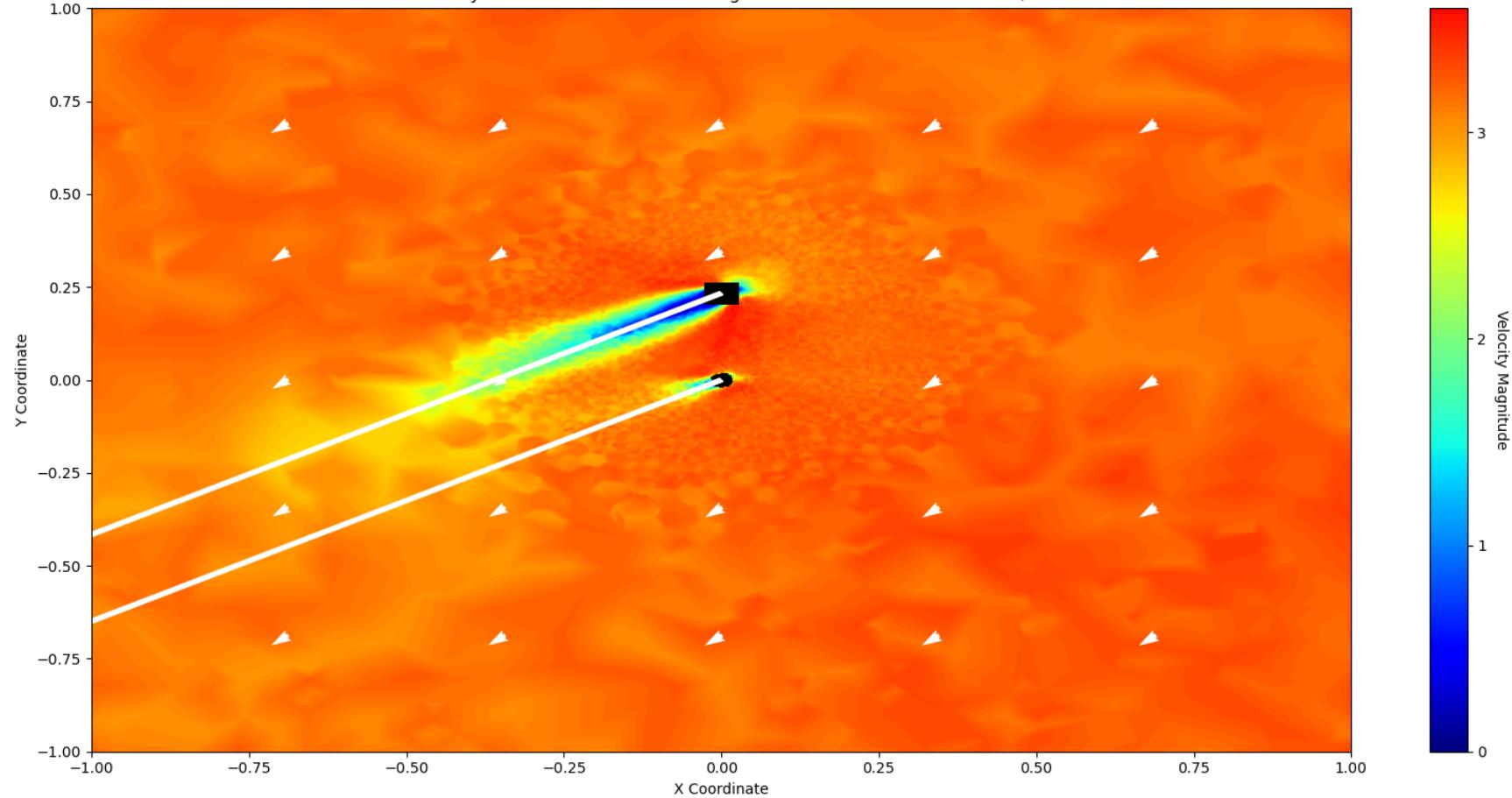
Total Velocity in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



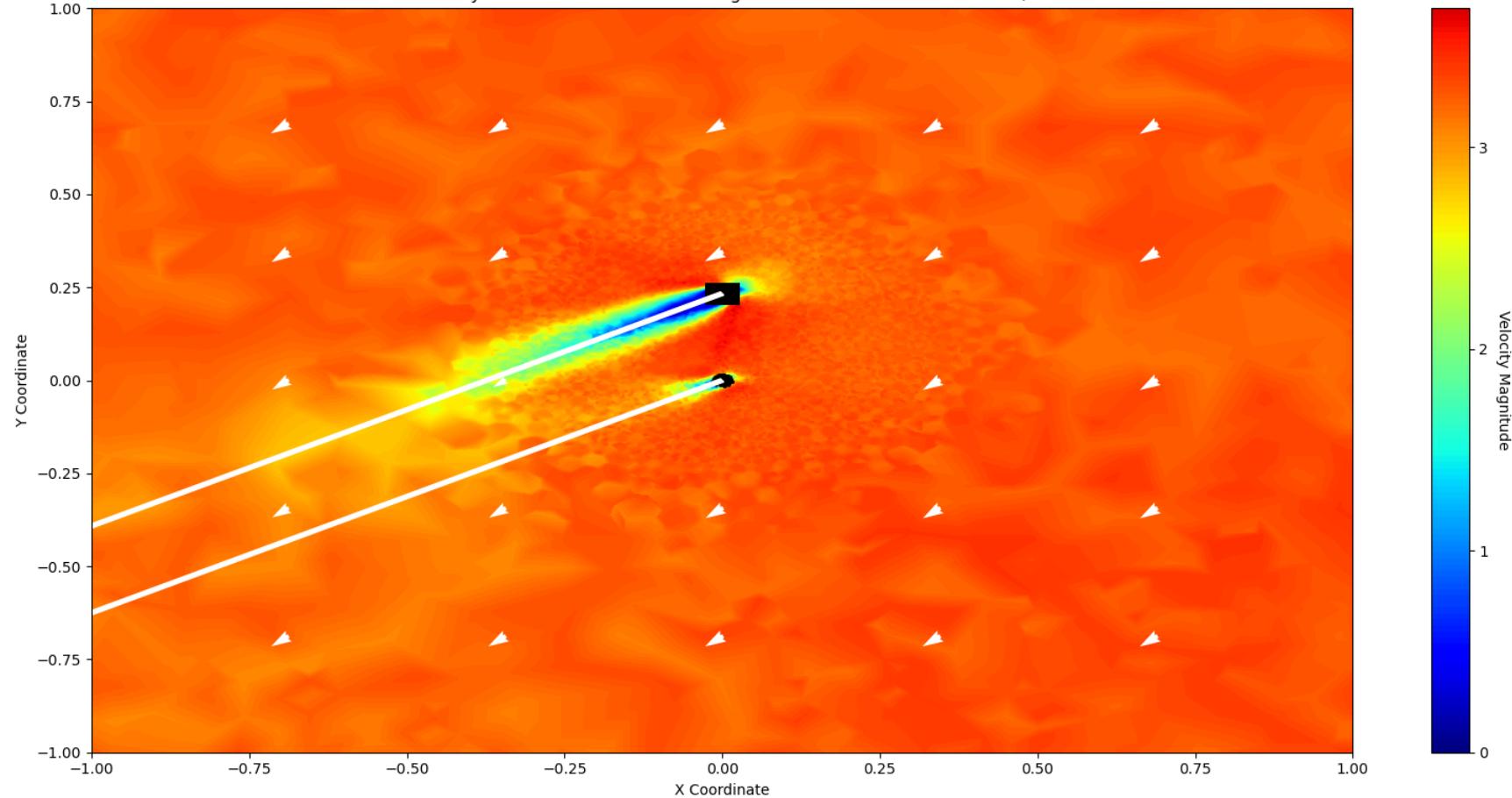
Total Velocity in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



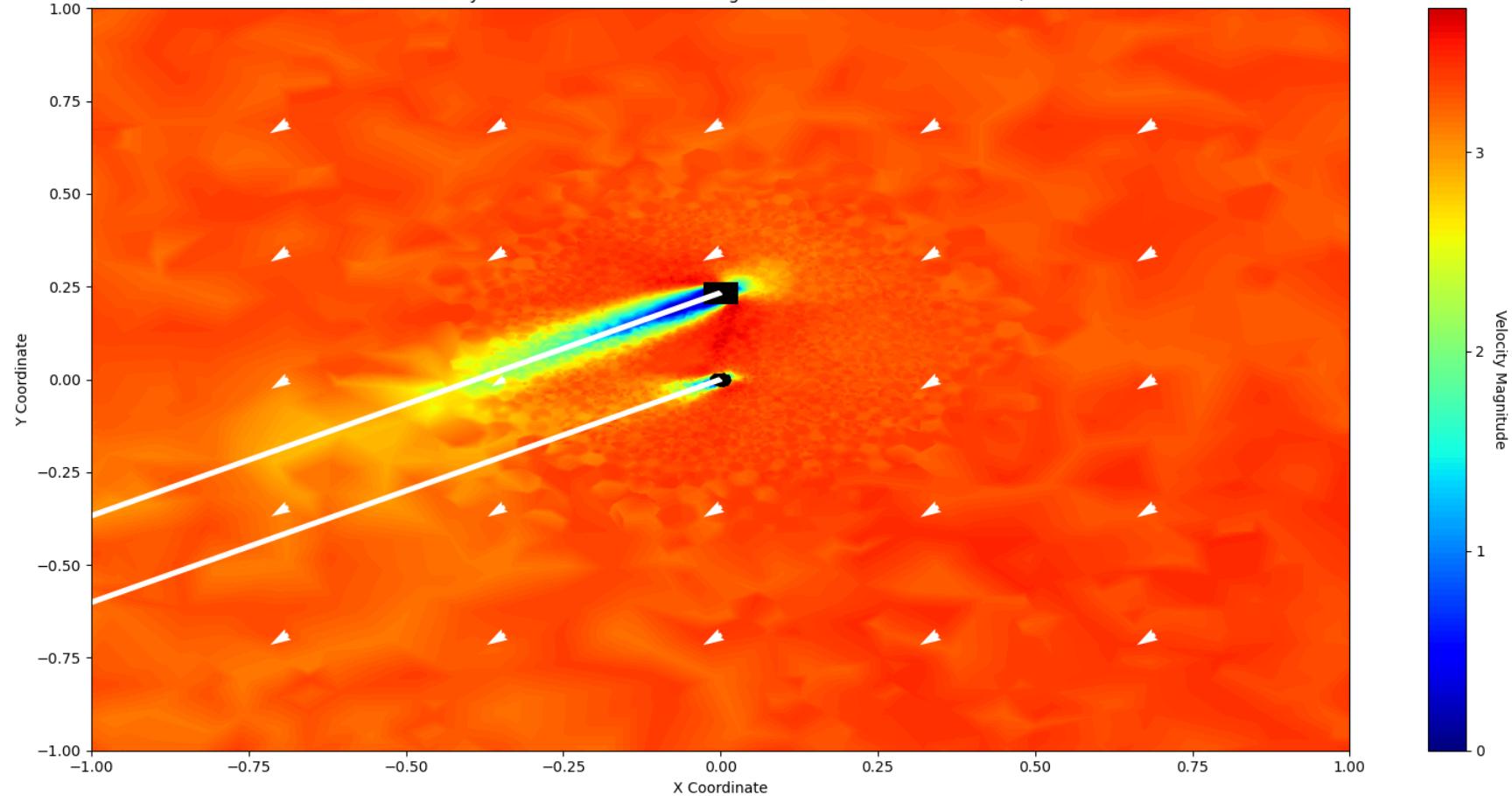
Total Velocity in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



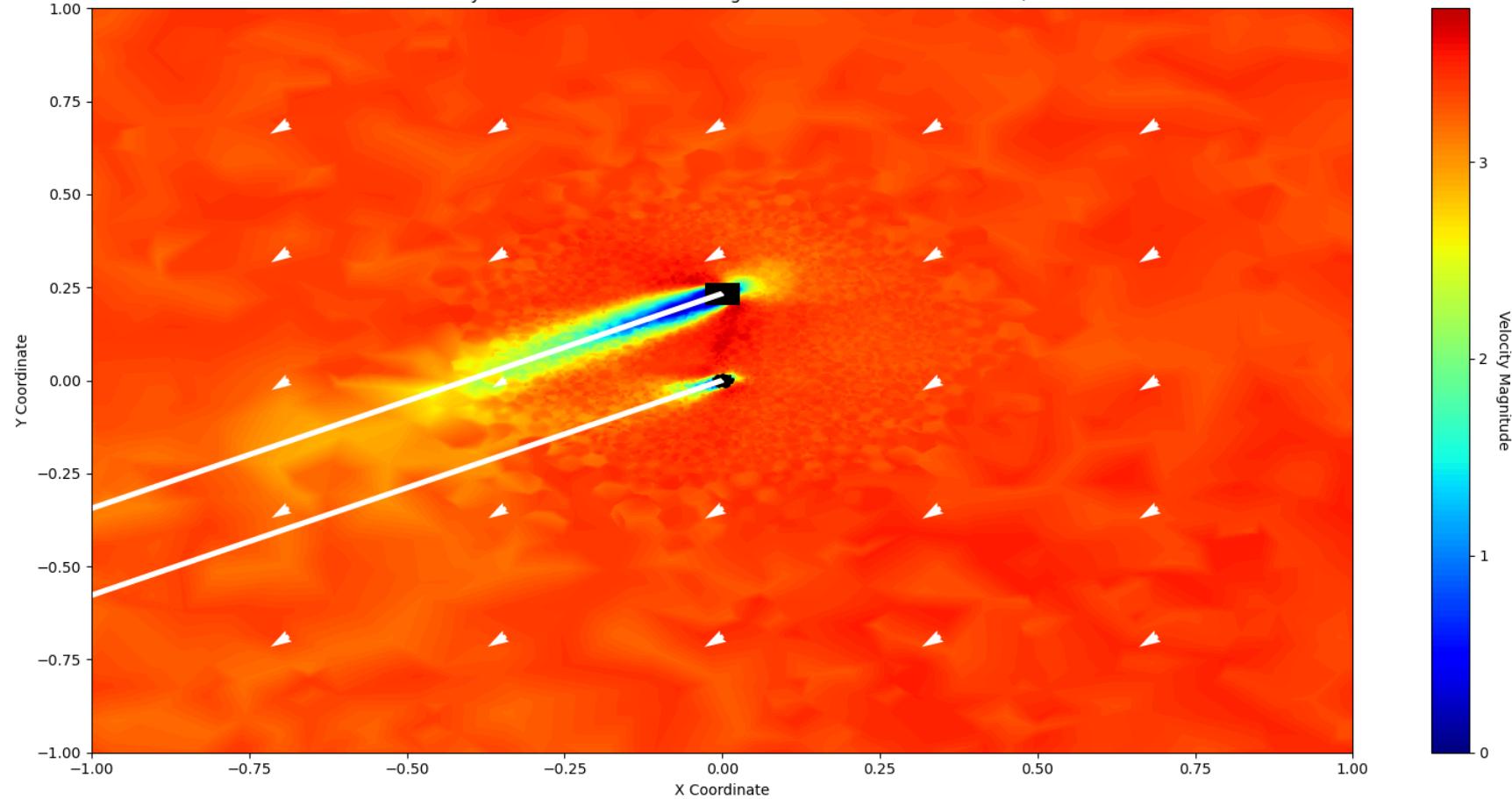
Total Velocity in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



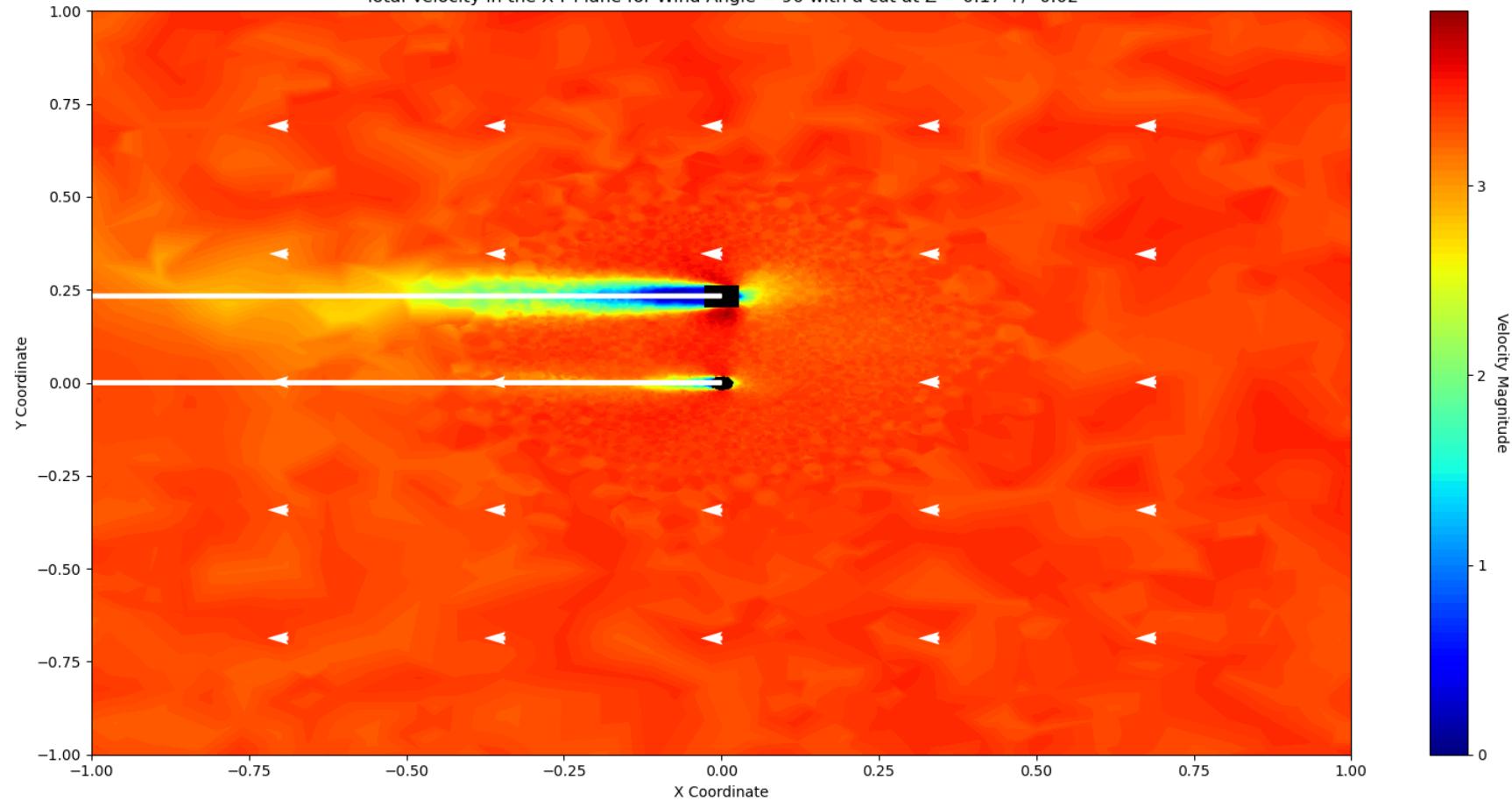
Total Velocity in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



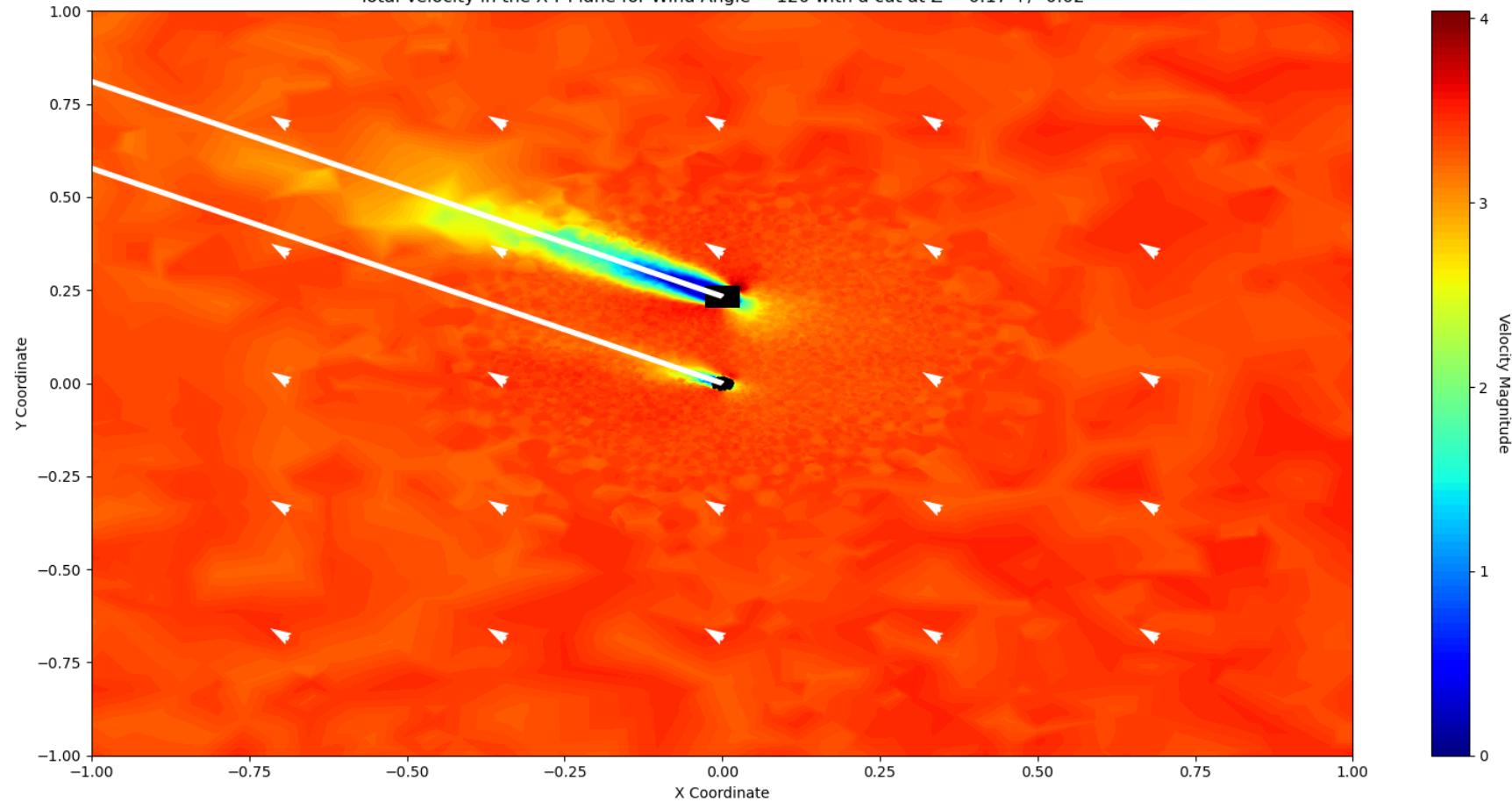
Total Velocity in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



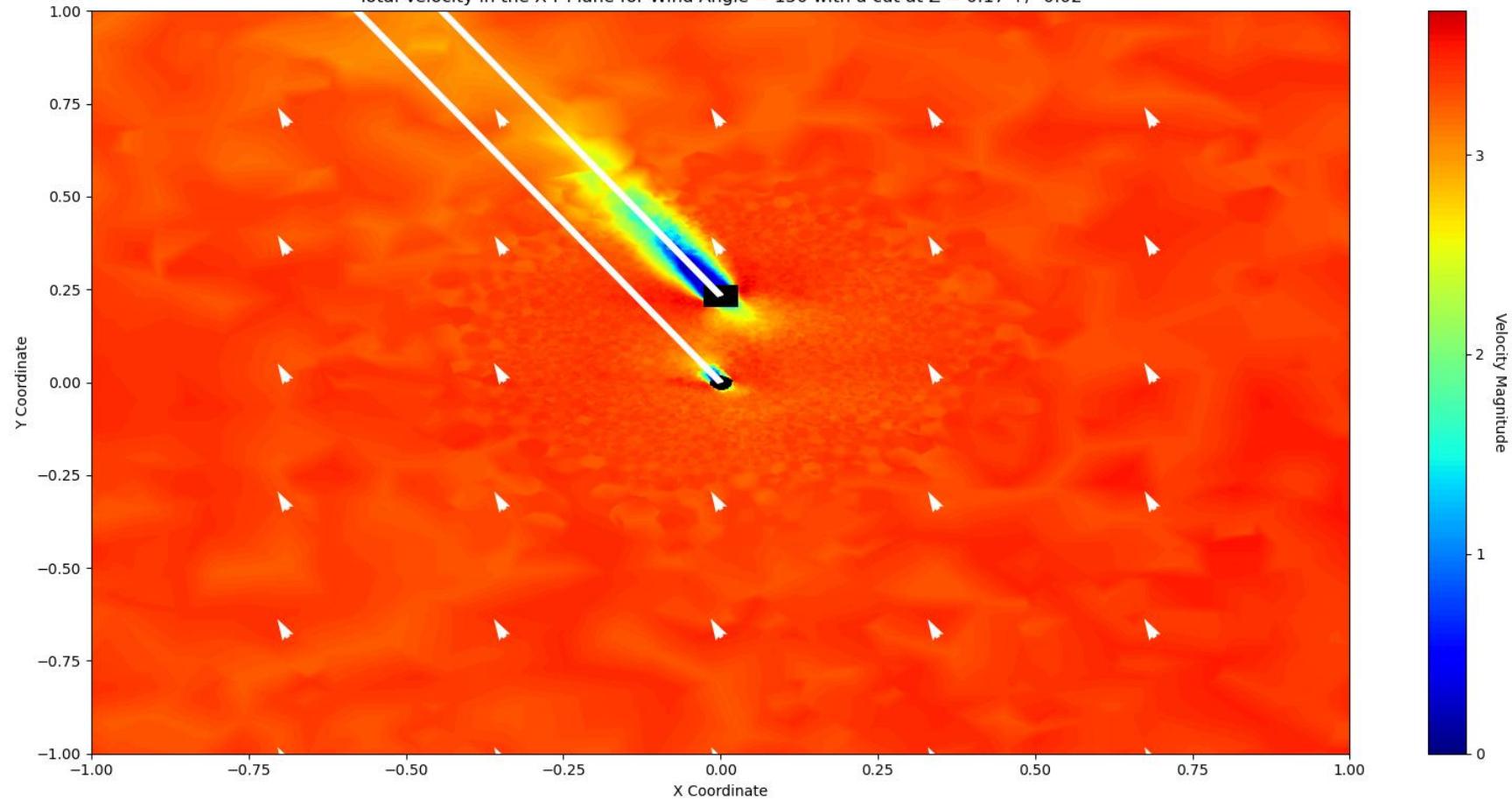
Total Velocity in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



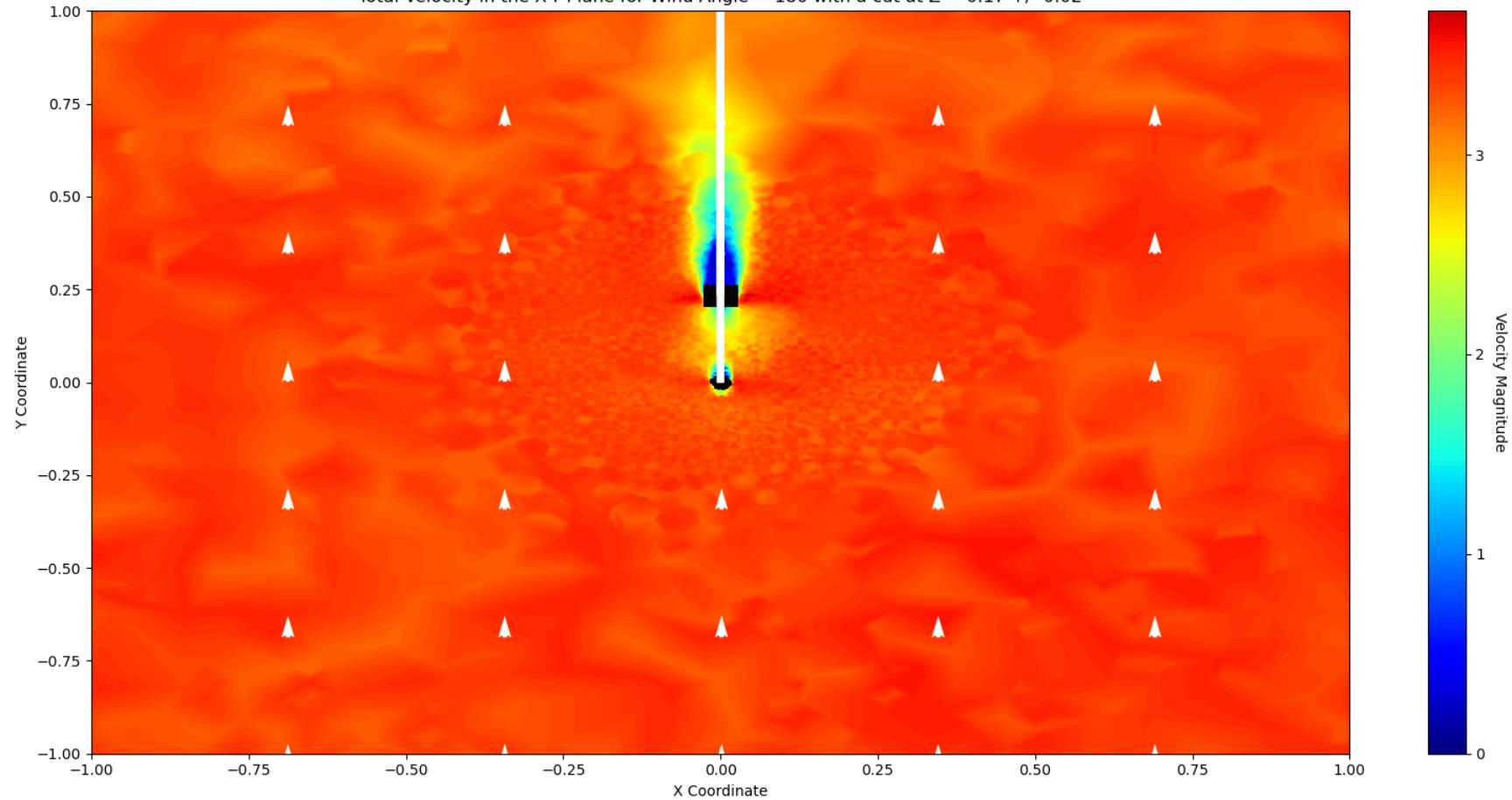
Total Velocity in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



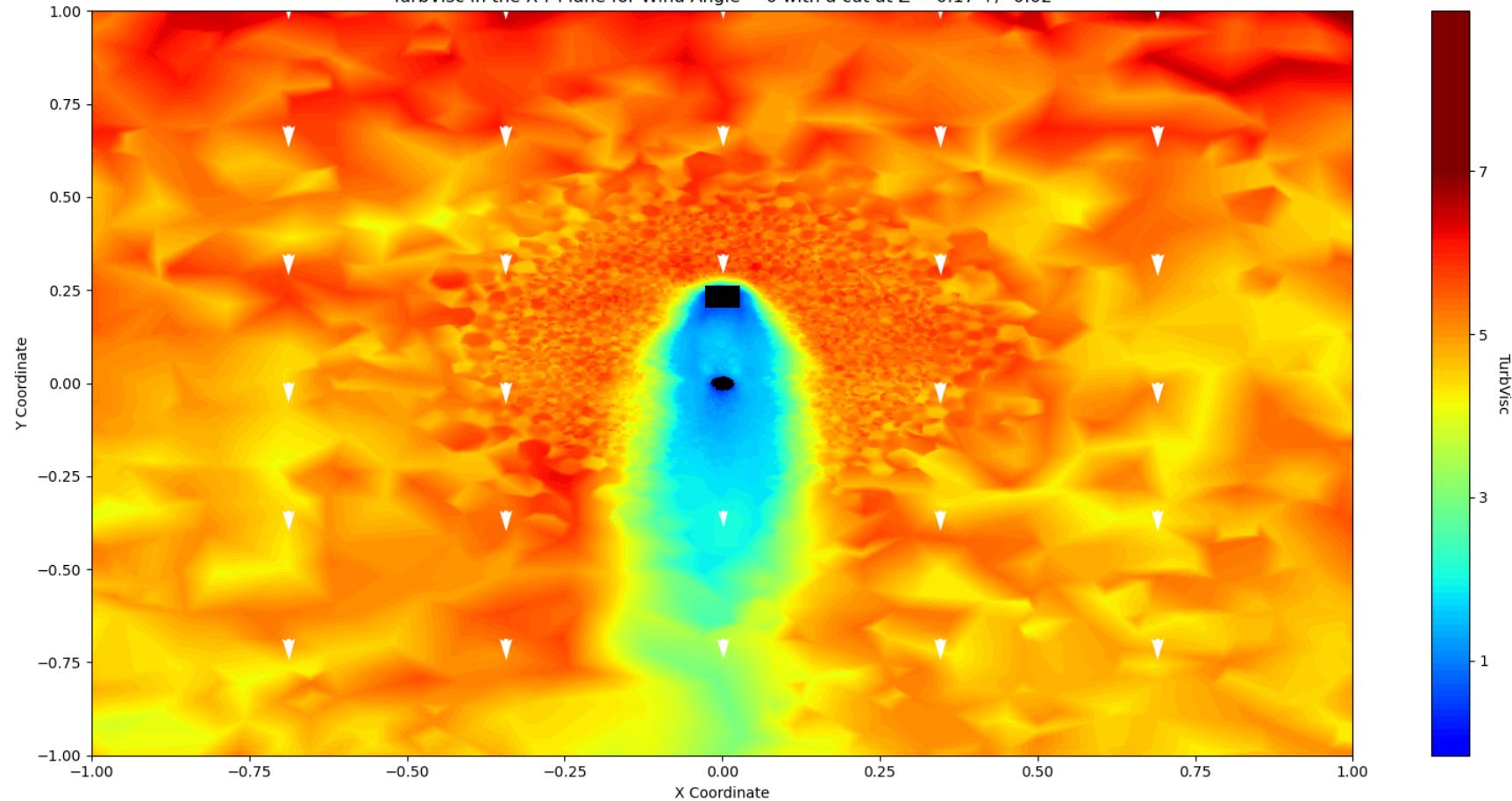
Total Velocity in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



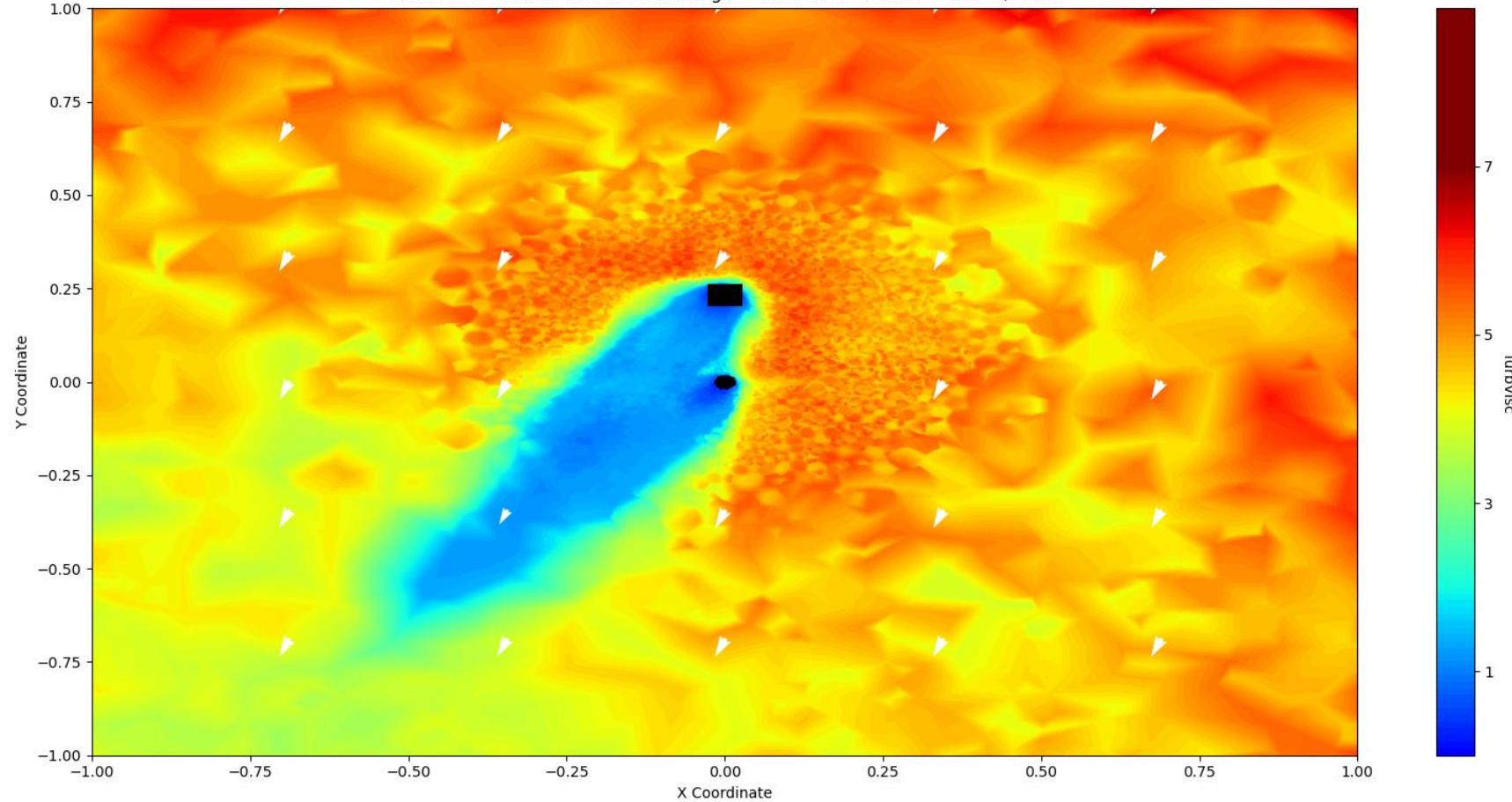
Total Velocity in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



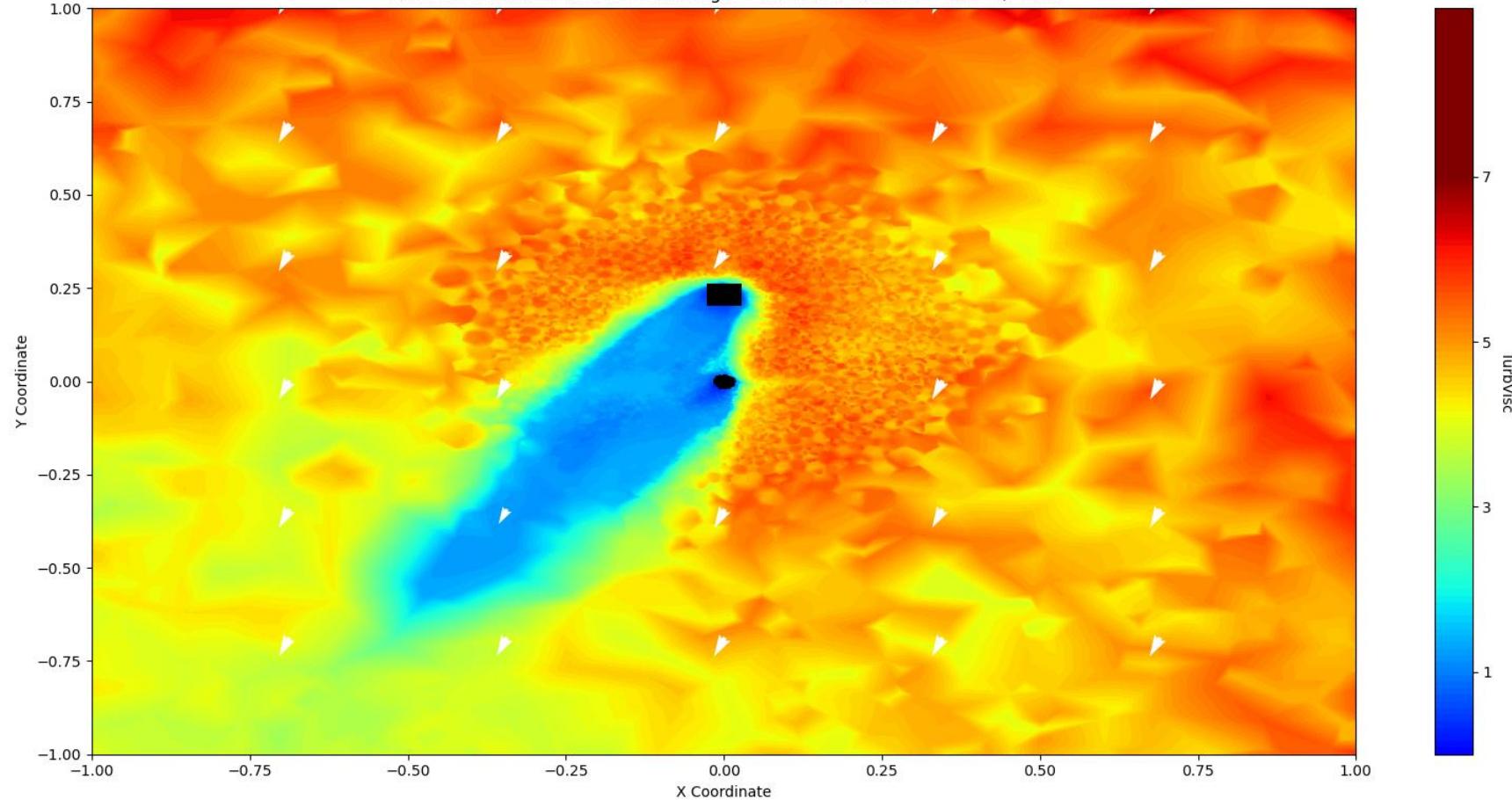
TurbVisc in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



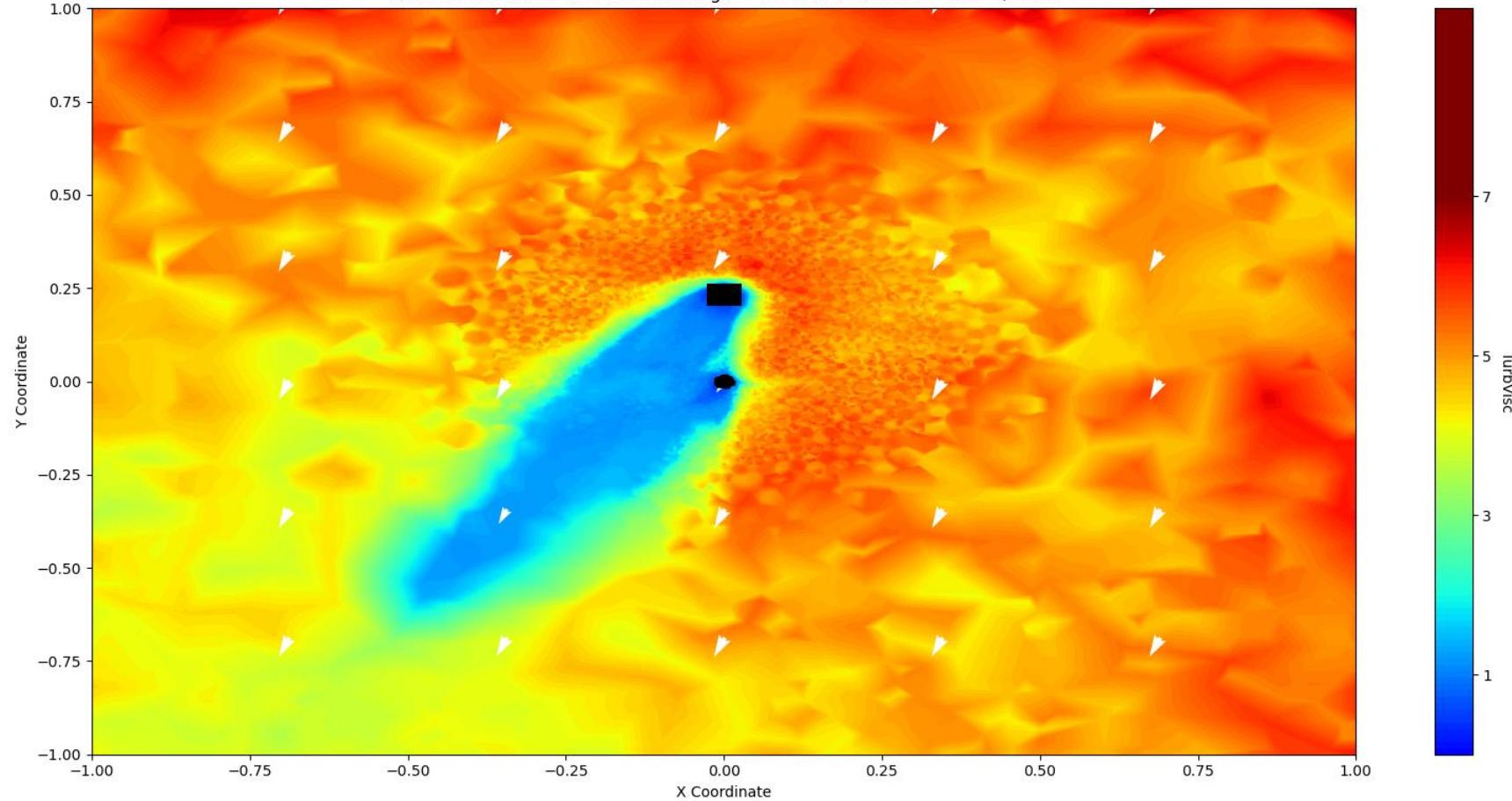
TurbVisc in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



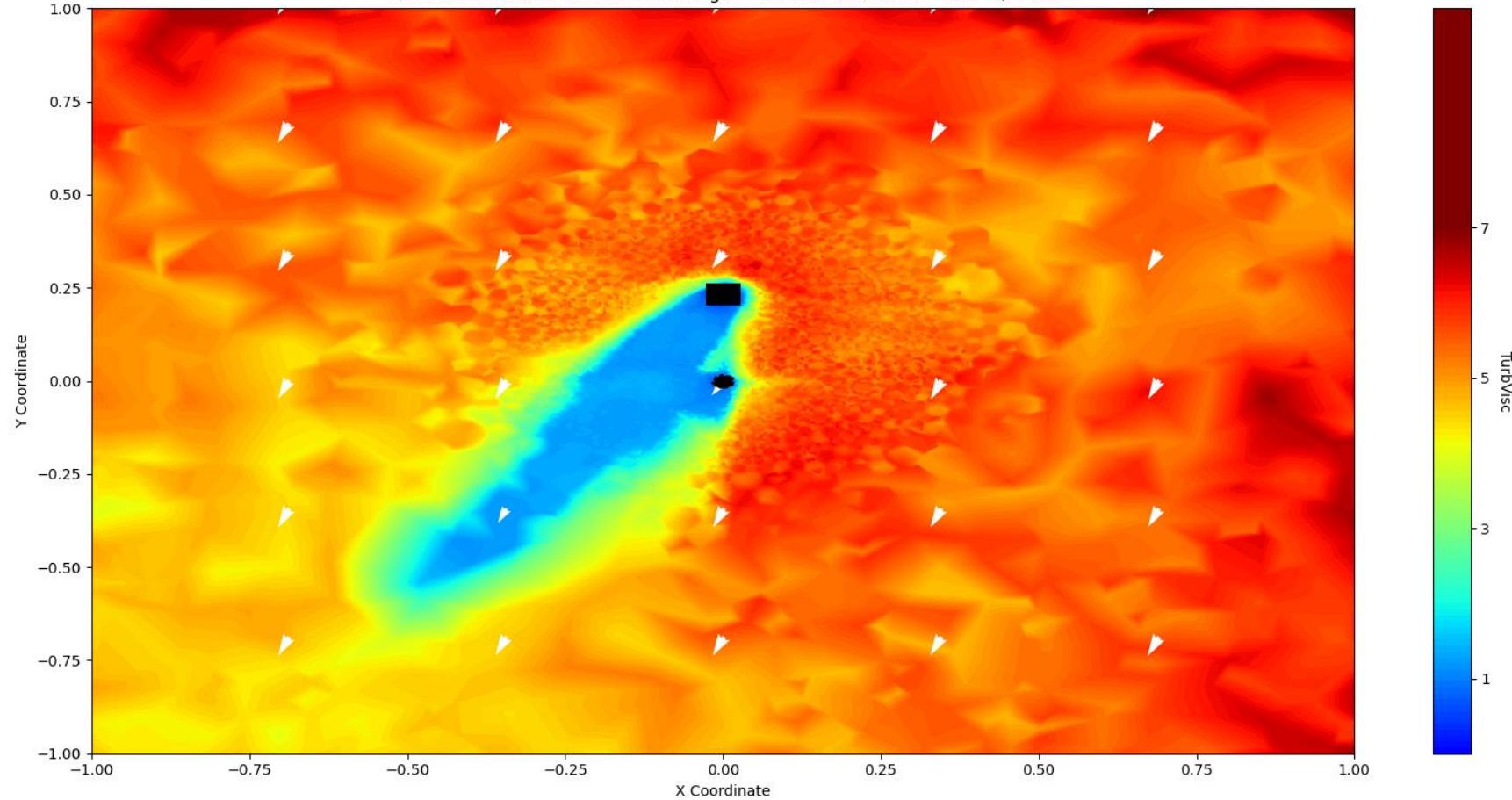
TurbVisc in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



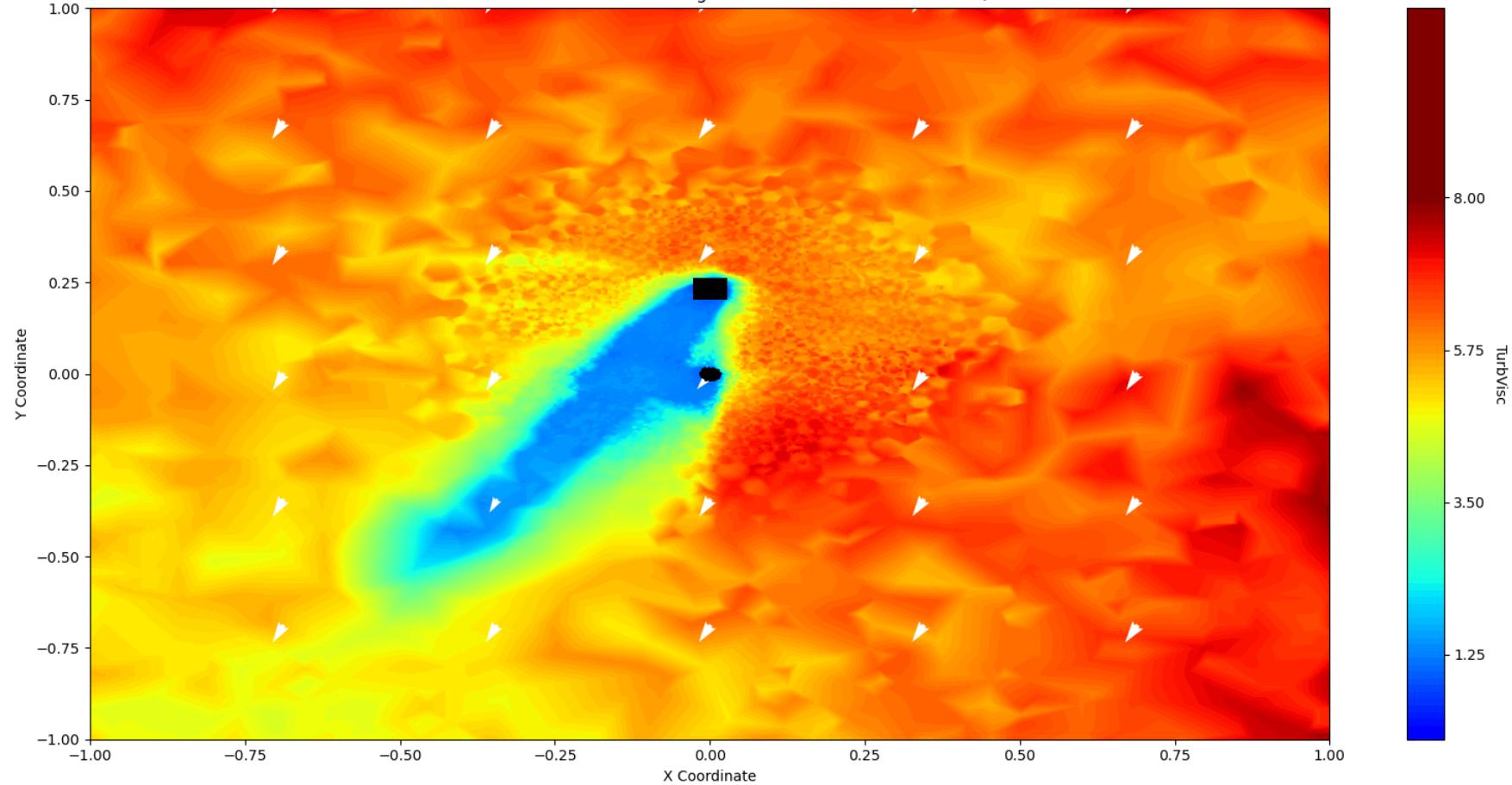
TurbVisc in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



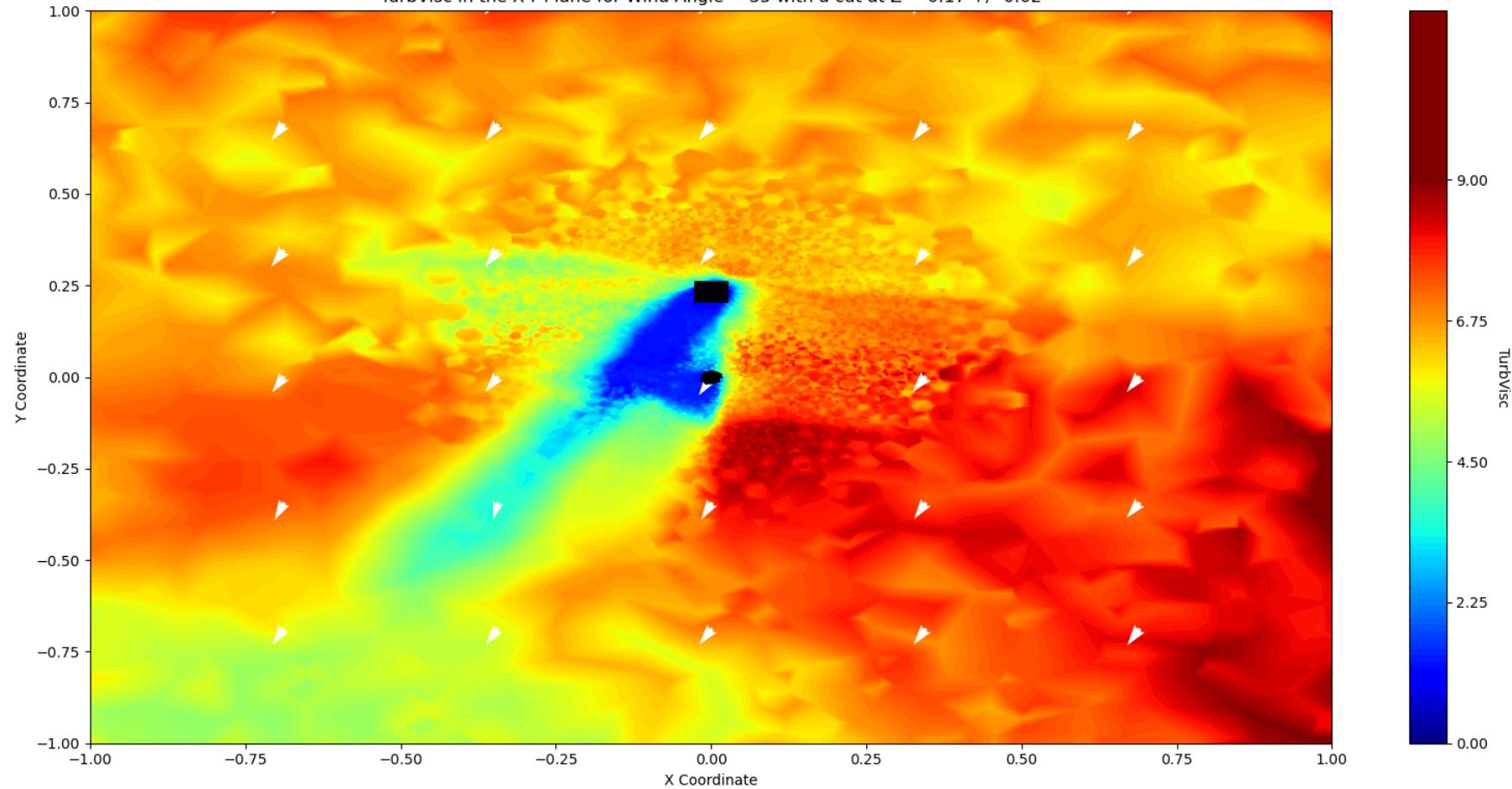
TurbVisc in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



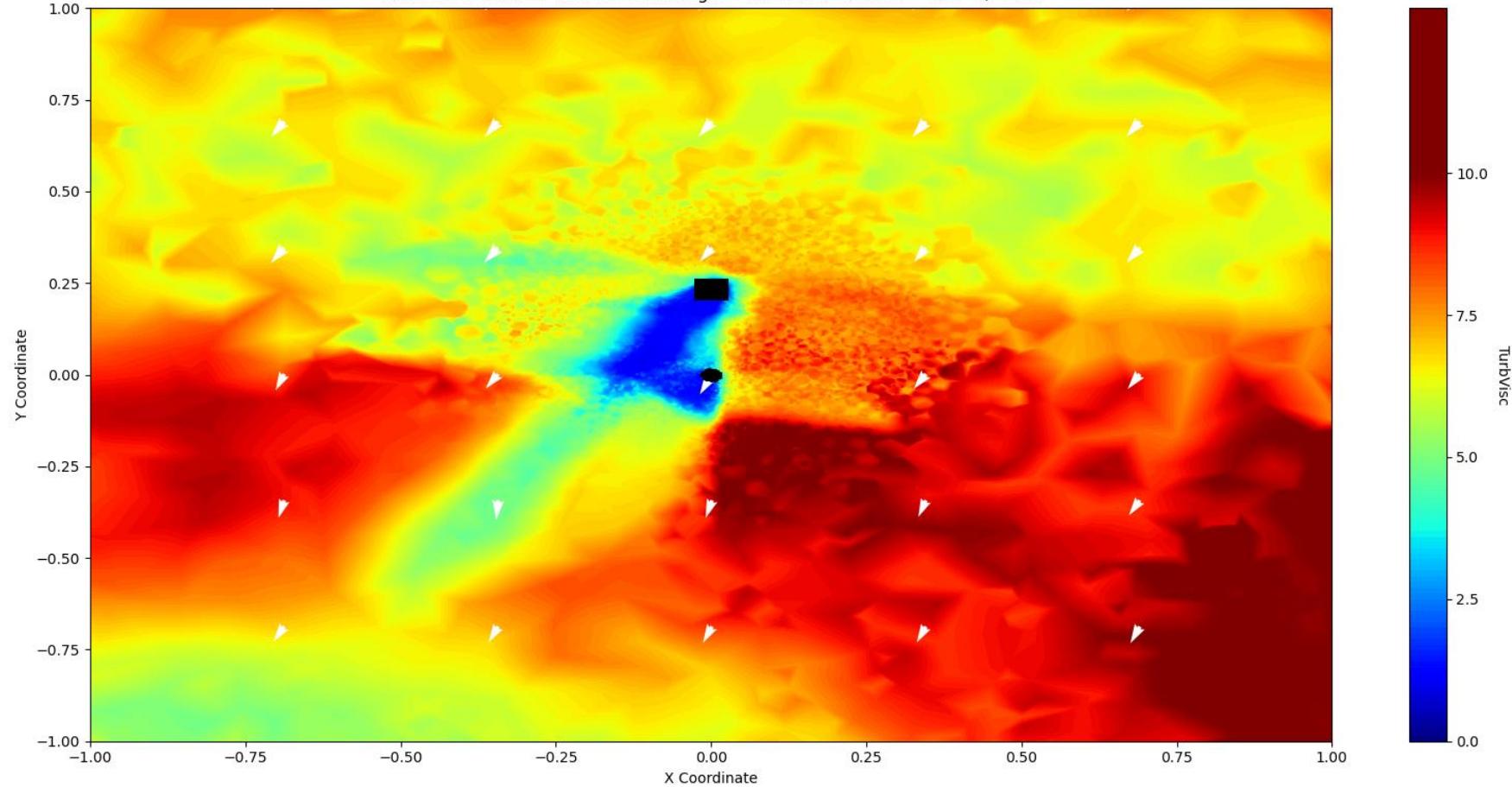
TurbVisc in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



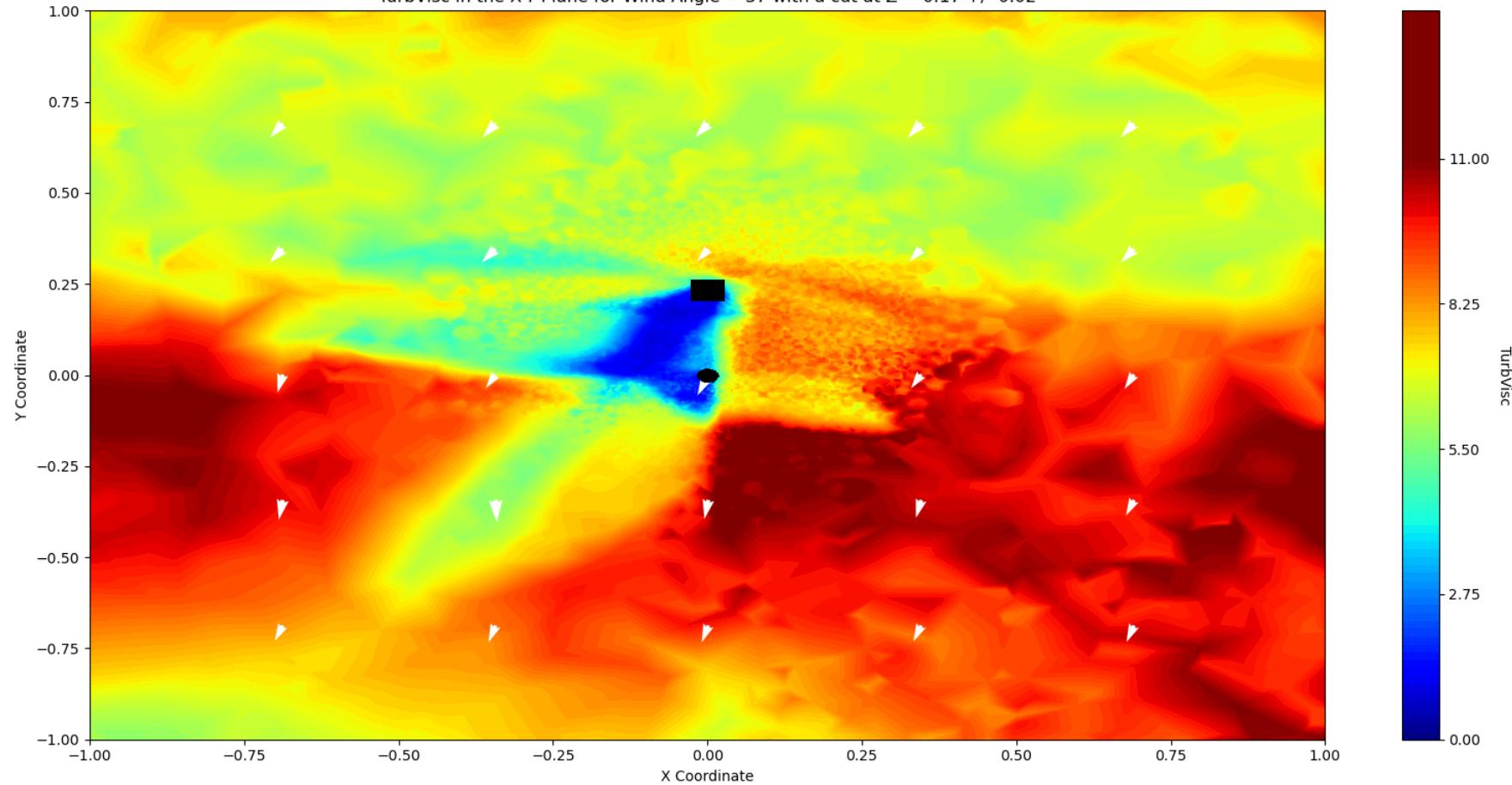
TurbVisc in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



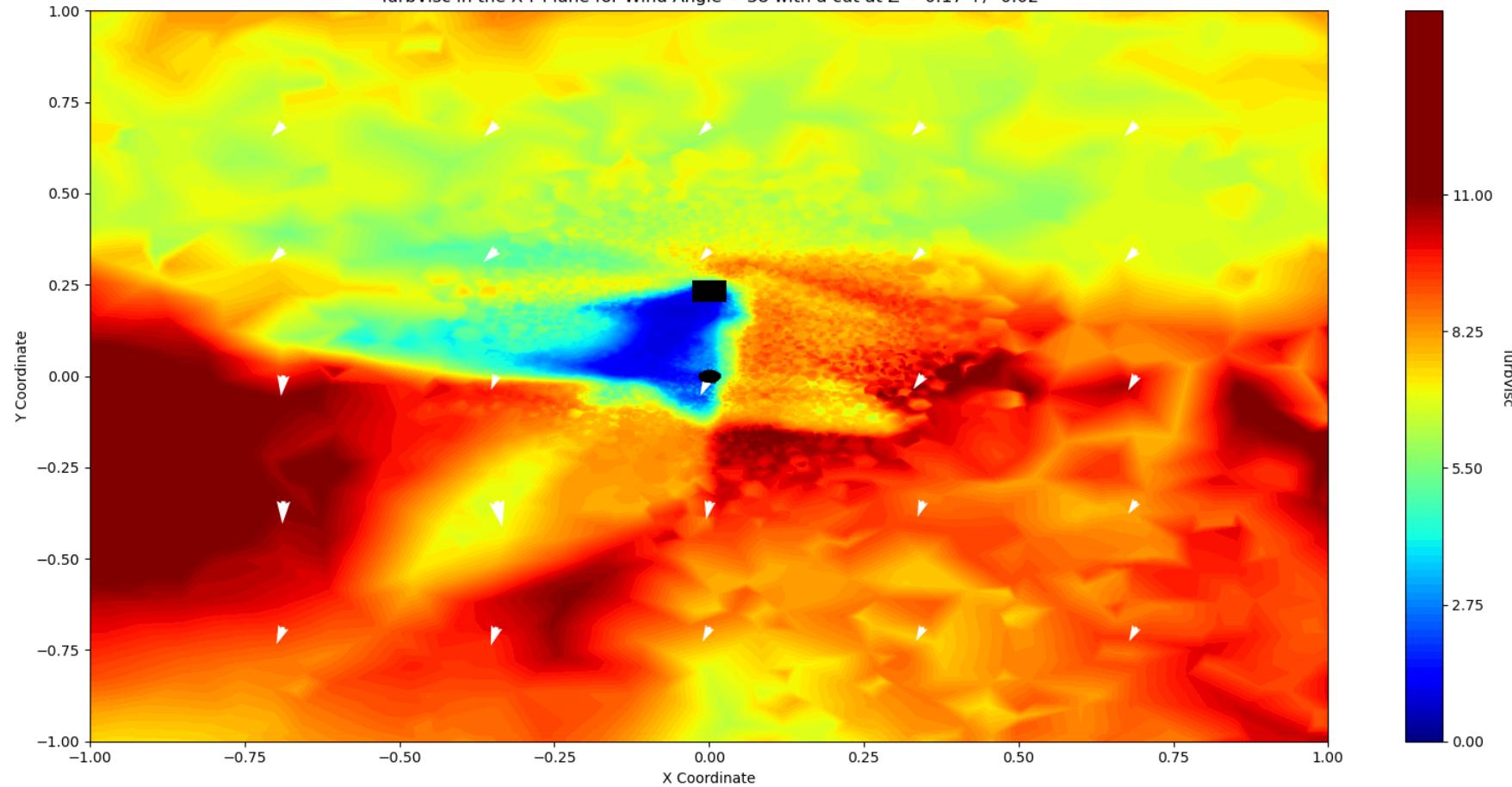
TurbVisc in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



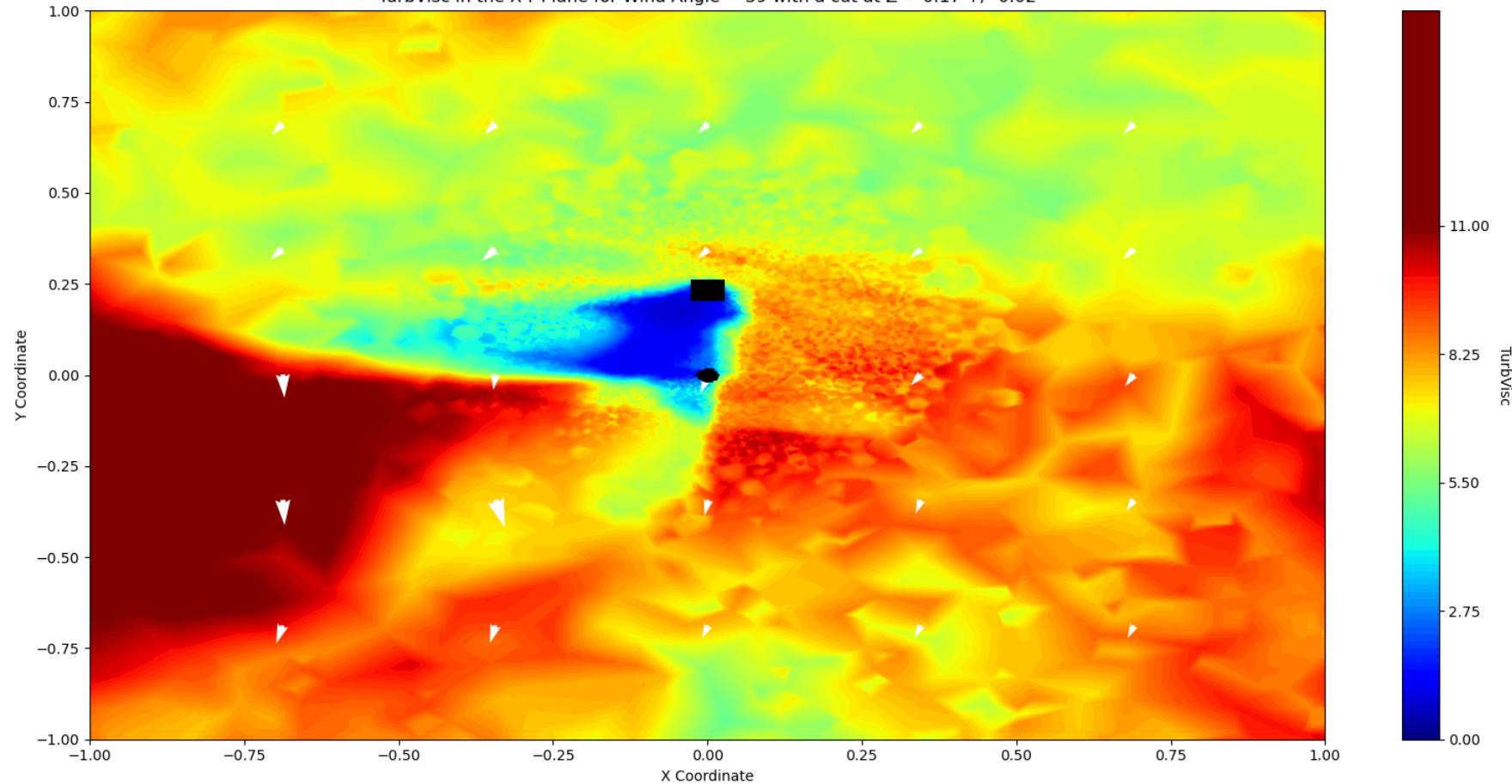
TurbVisc in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



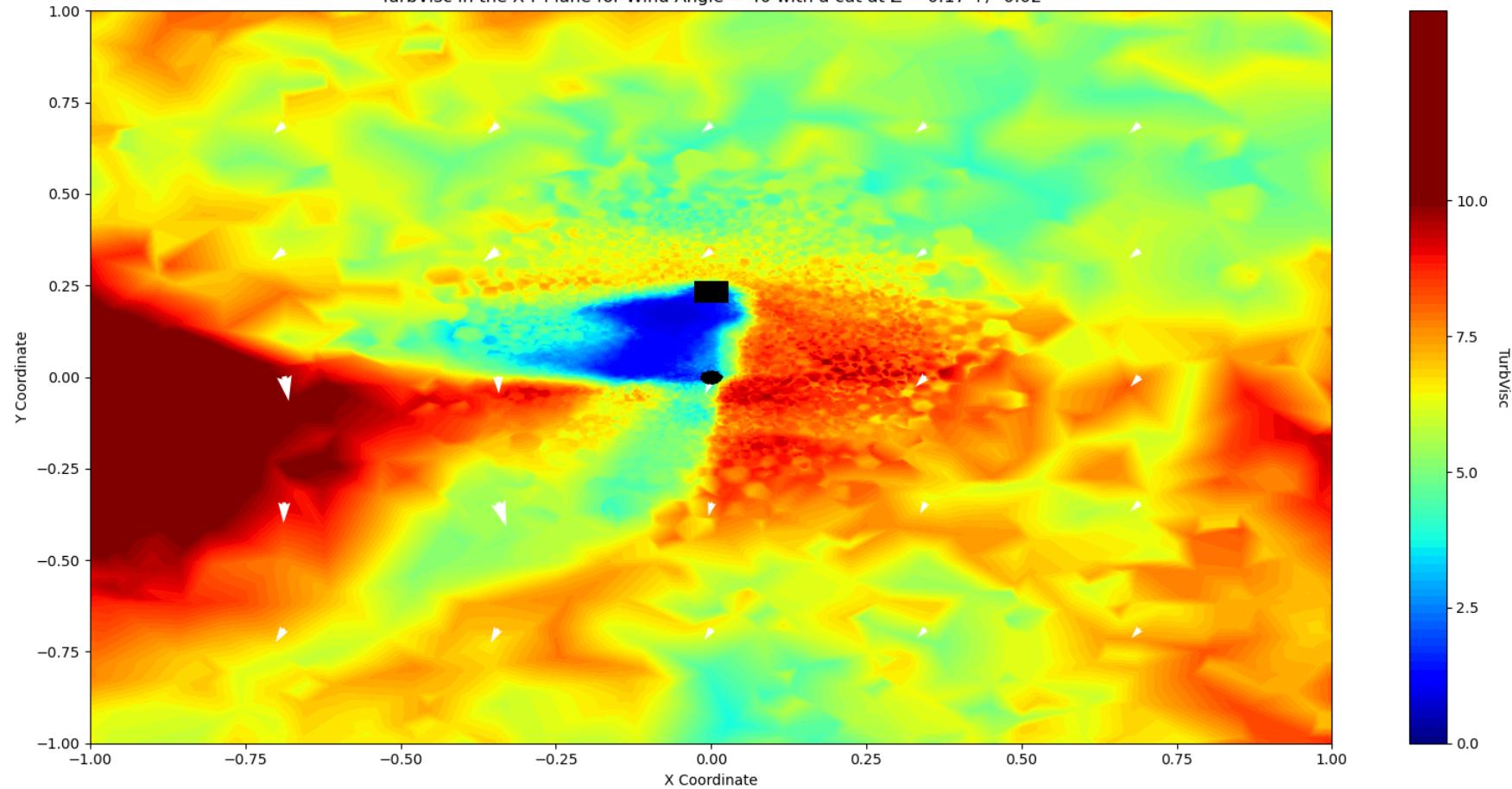
TurbVisc in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



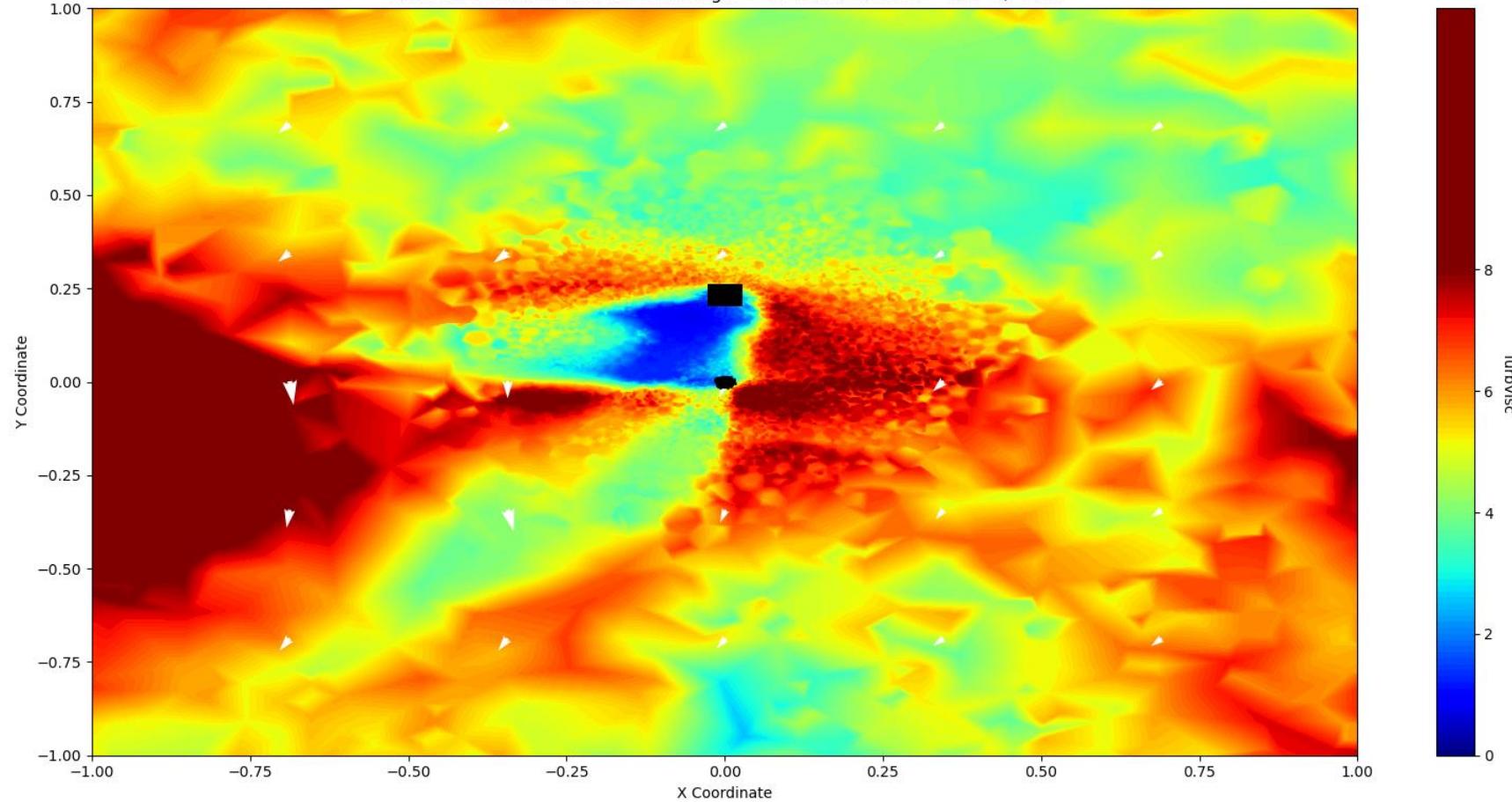
TurbVisc in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



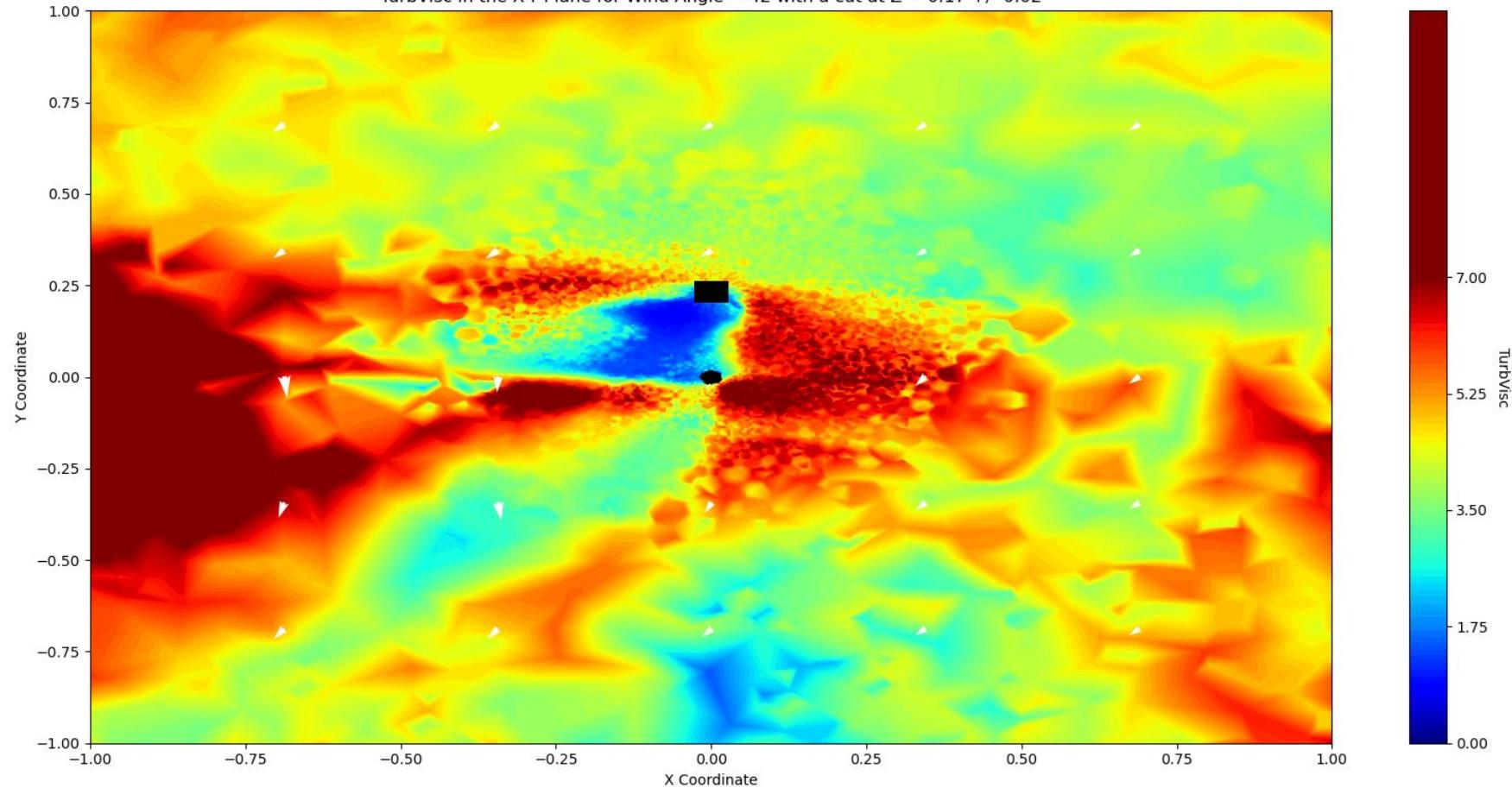
TurbVisc in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



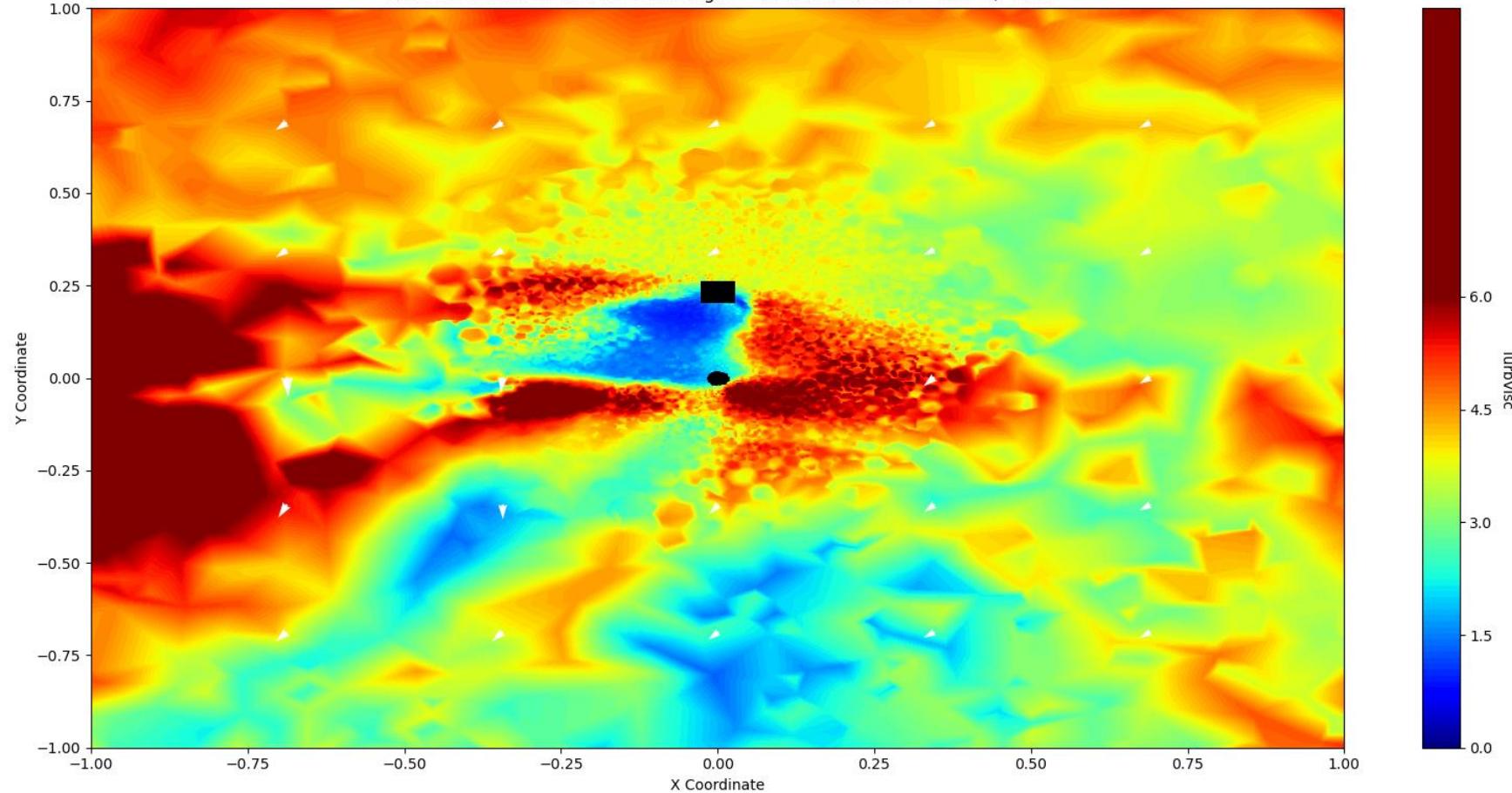
TurbVisc in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



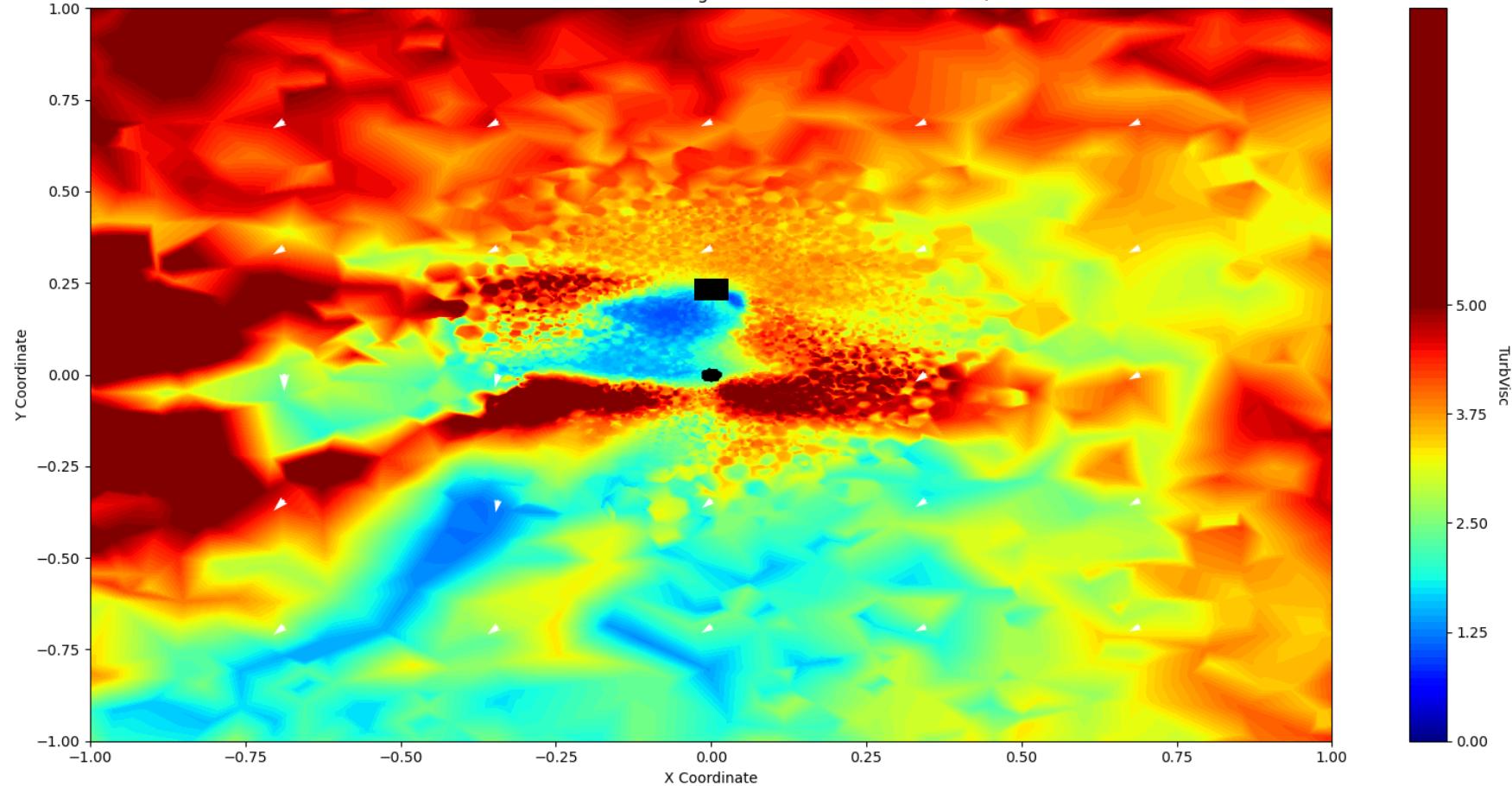
TurbVisc in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



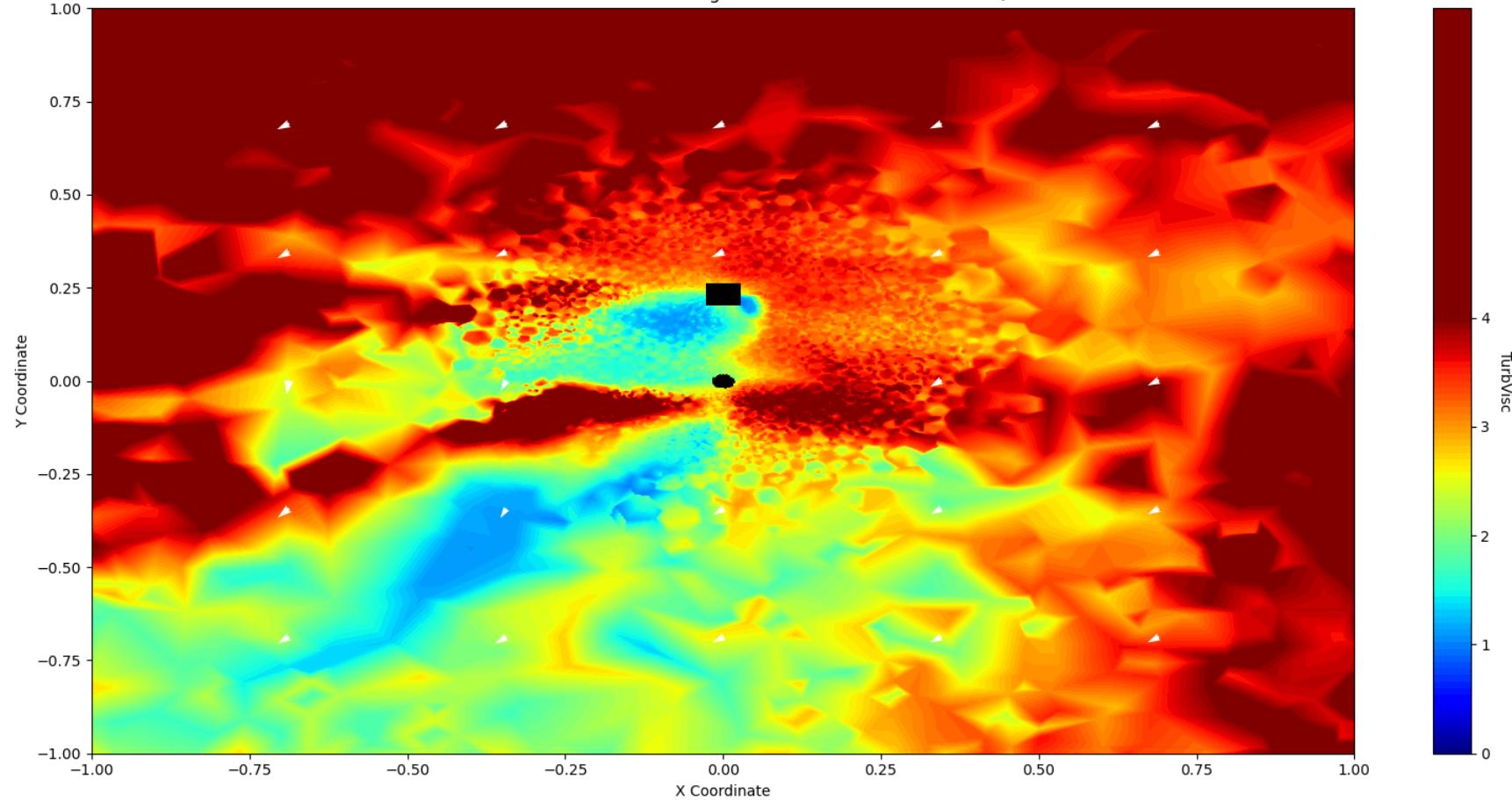
TurbVisc in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



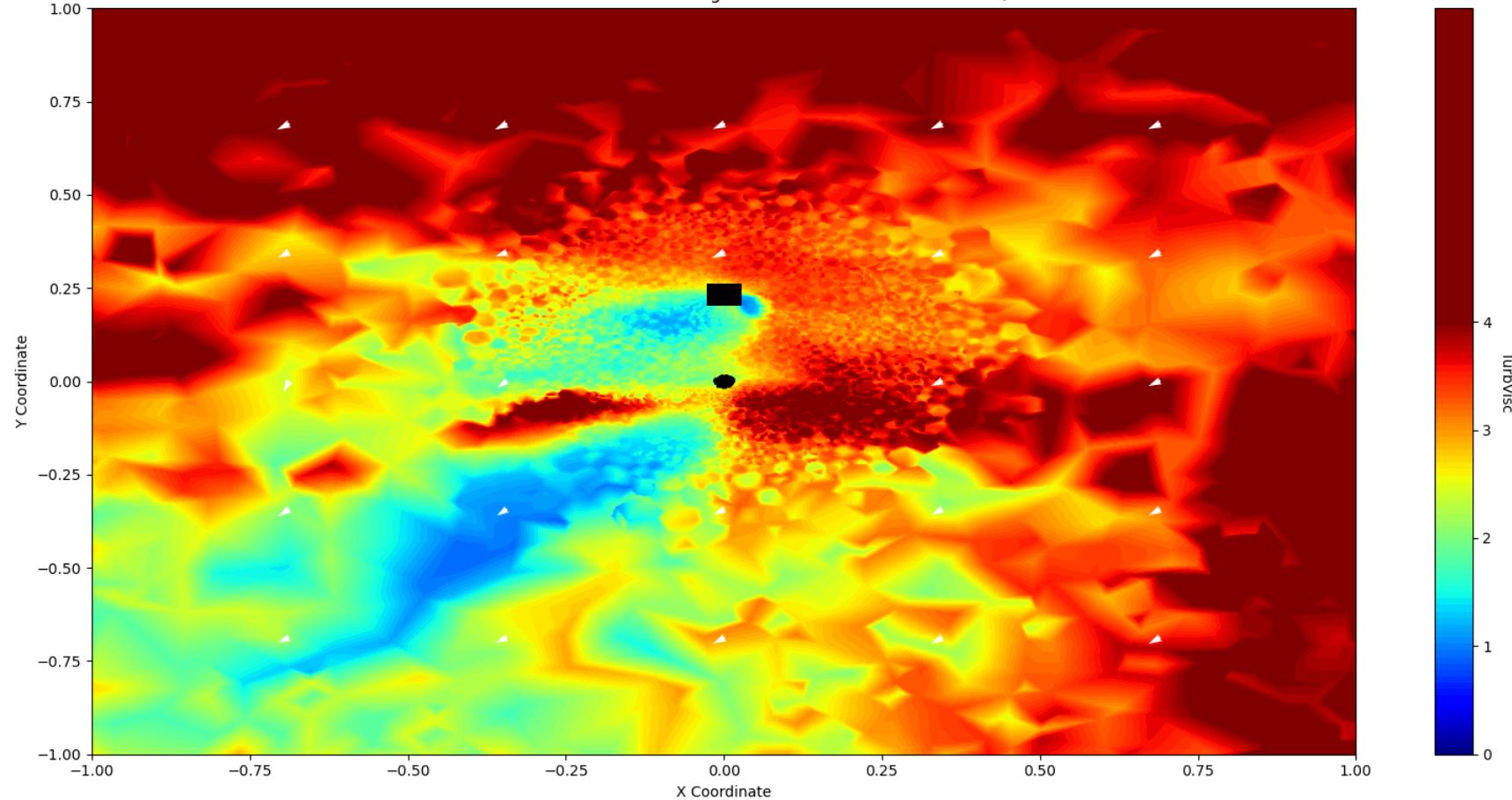
TurbVisc in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



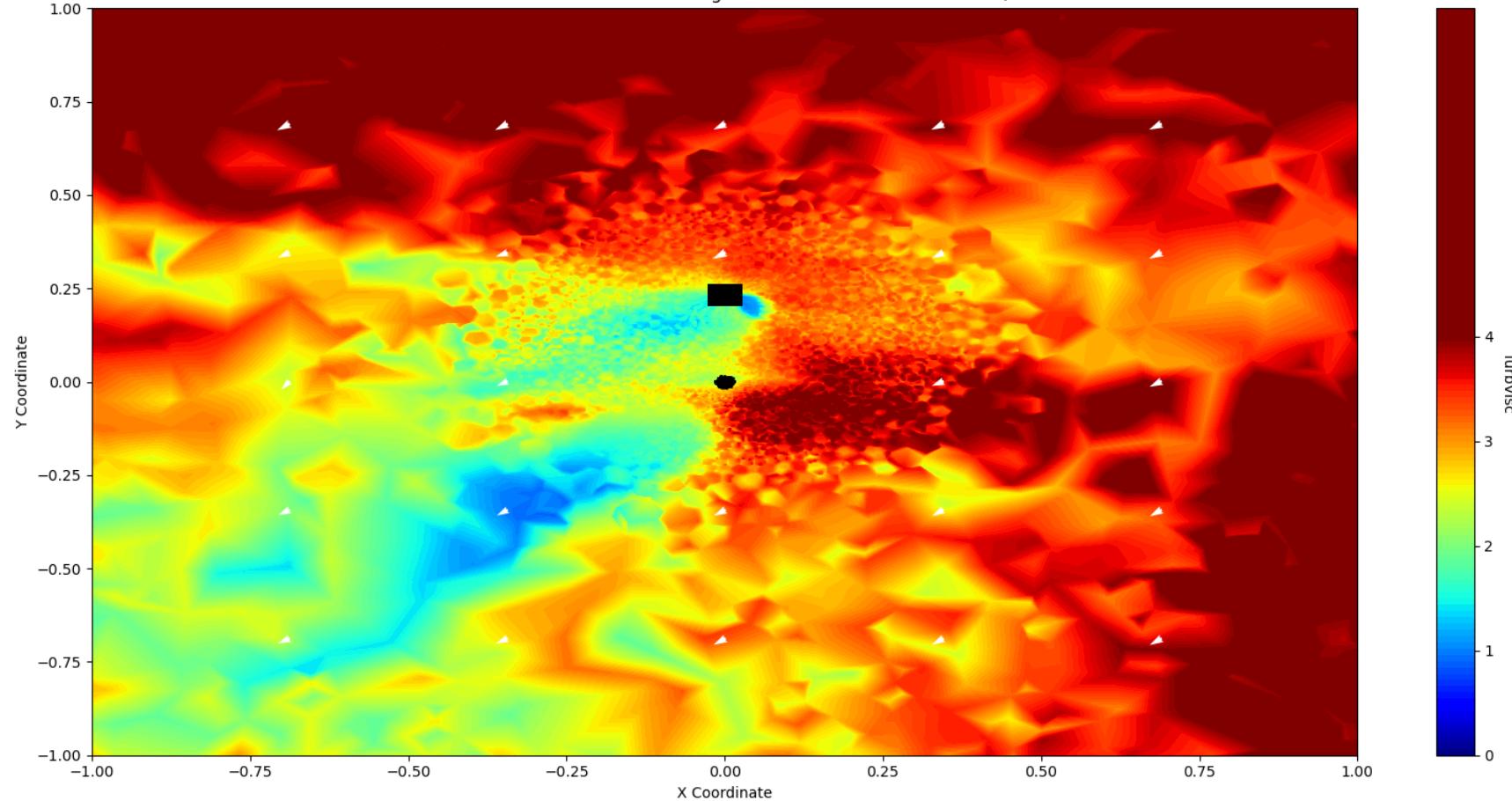
TurbVisc in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



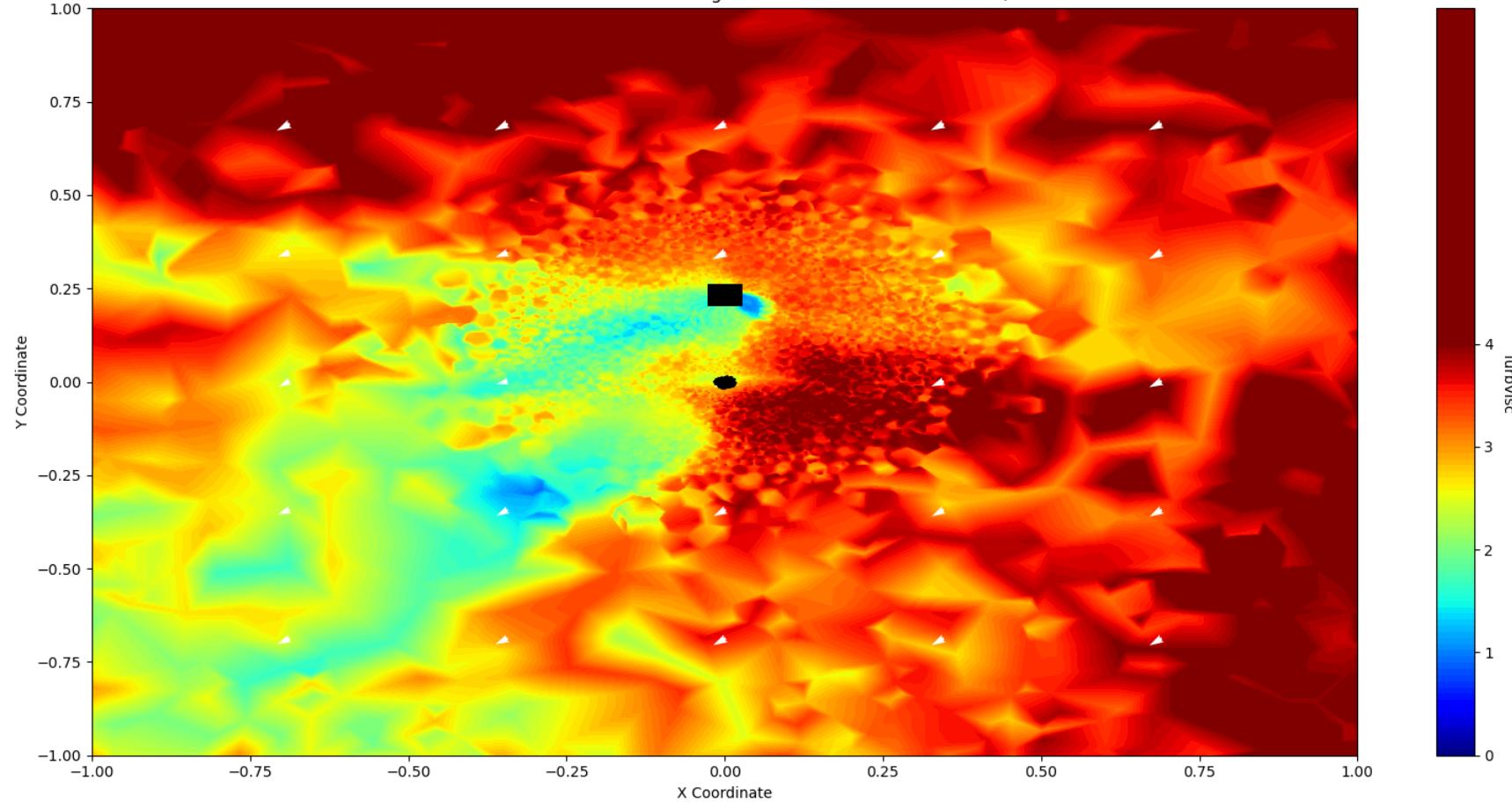
TurbVisc in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



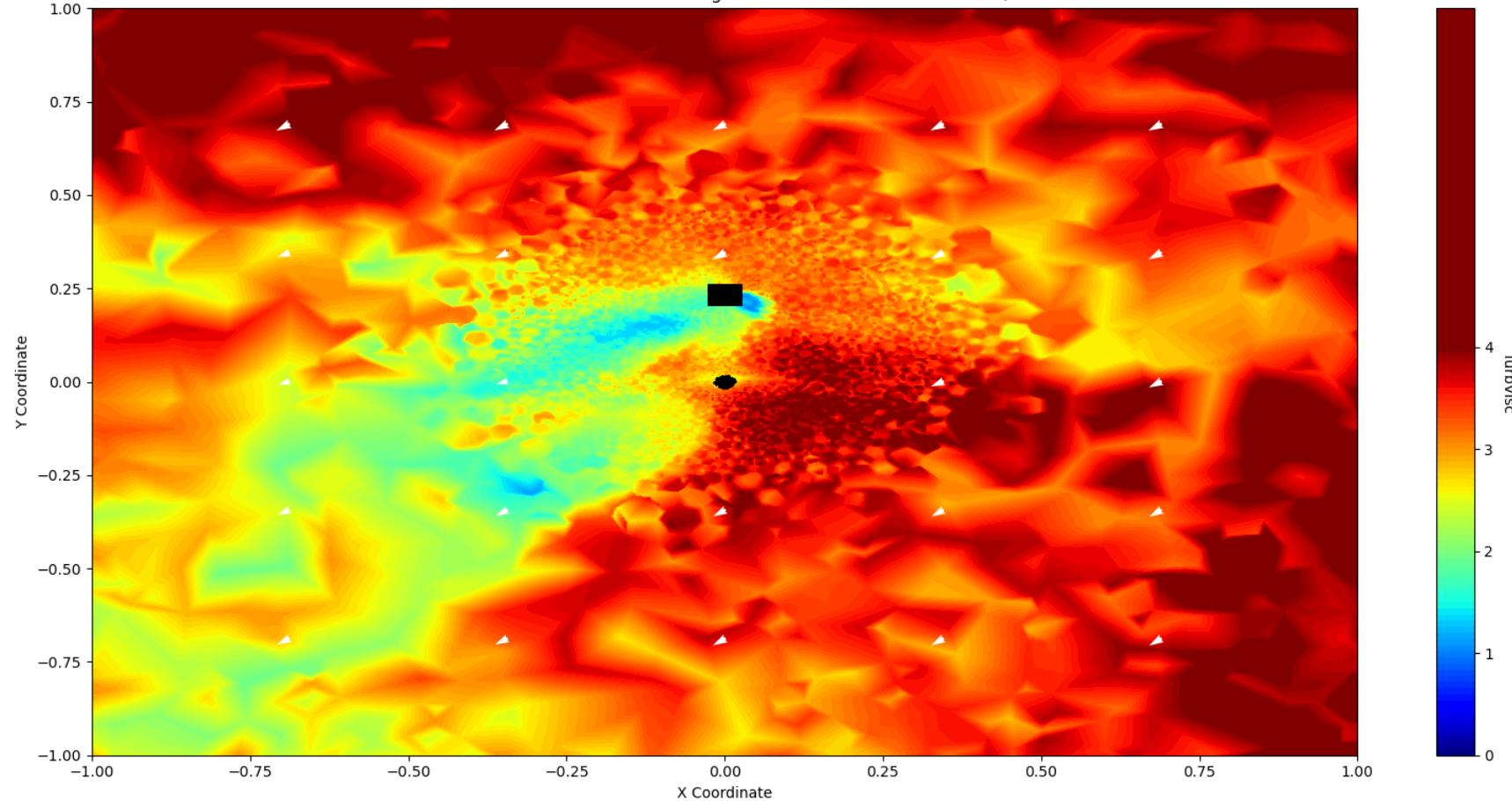
TurbVisc in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



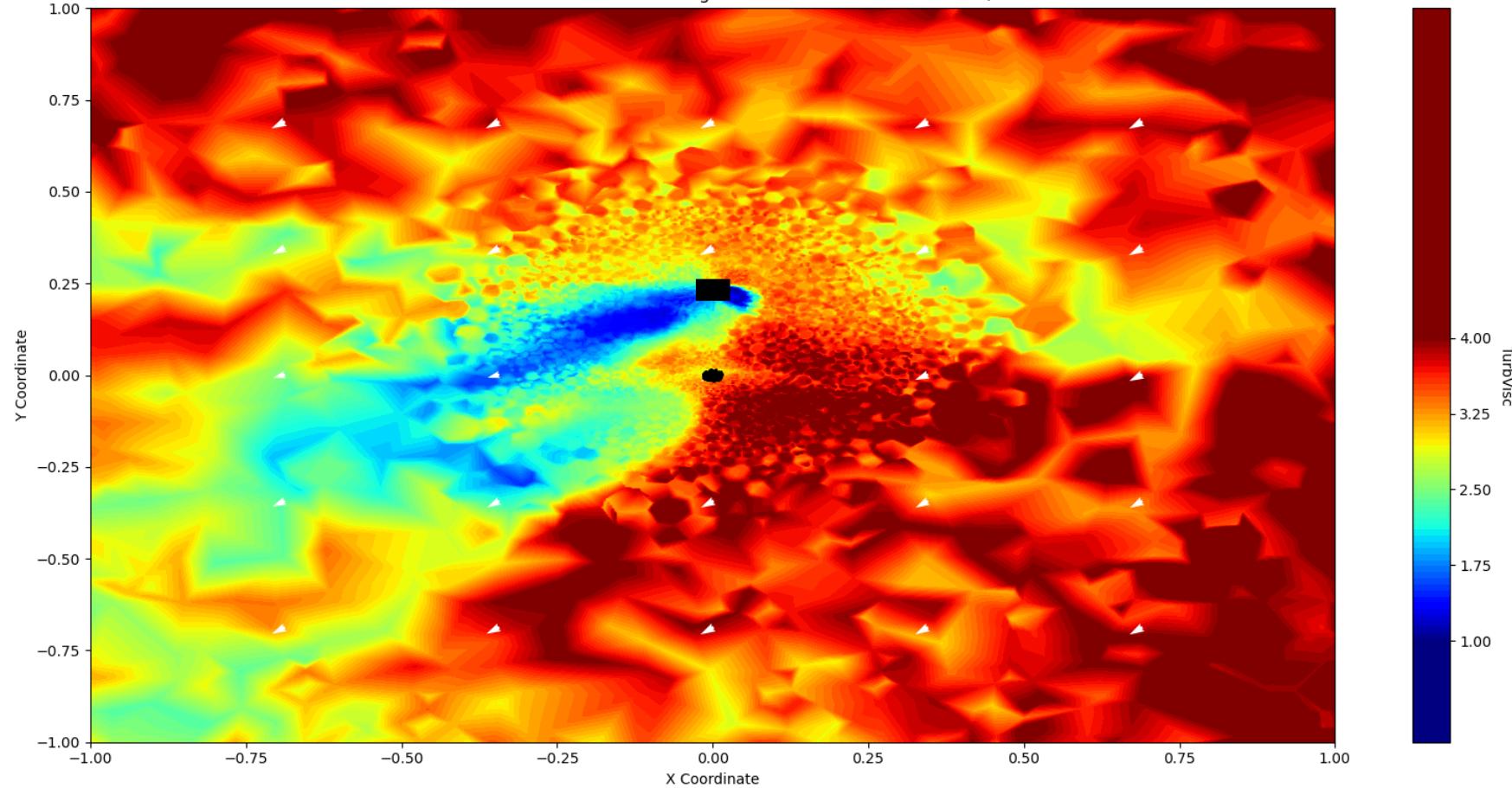
TurbVisc in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



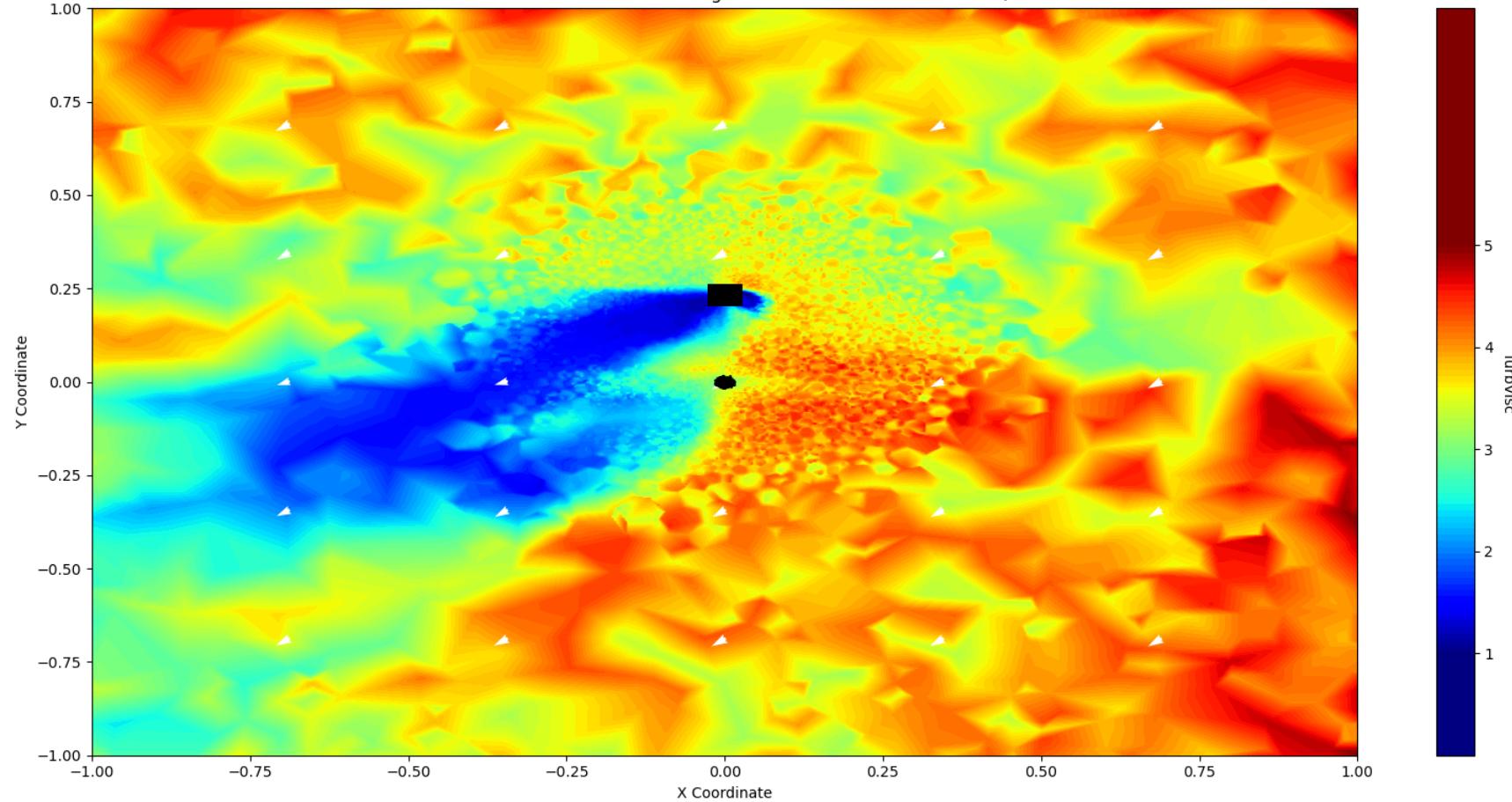
TurbVisc in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



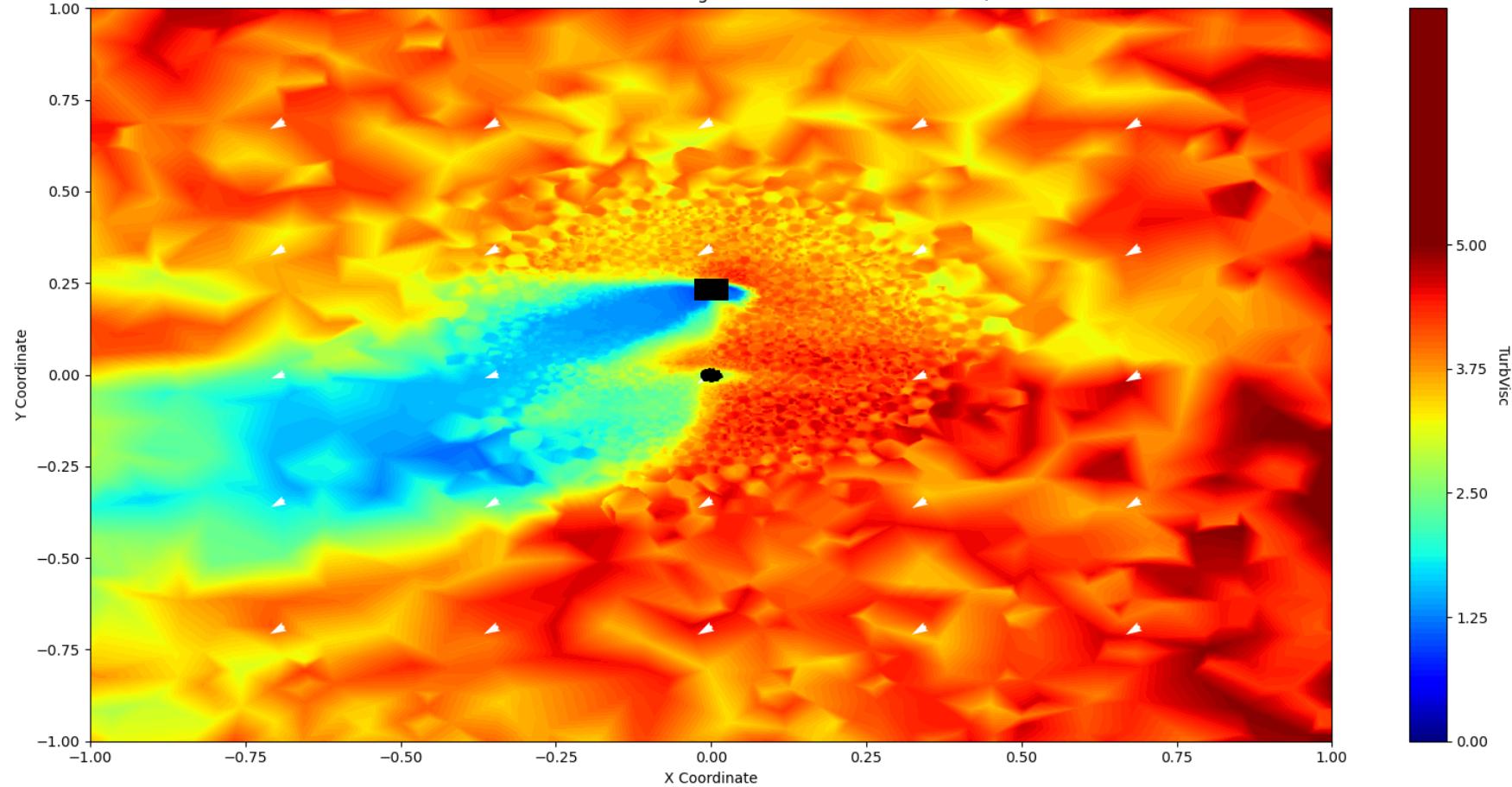
TurbVisc in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



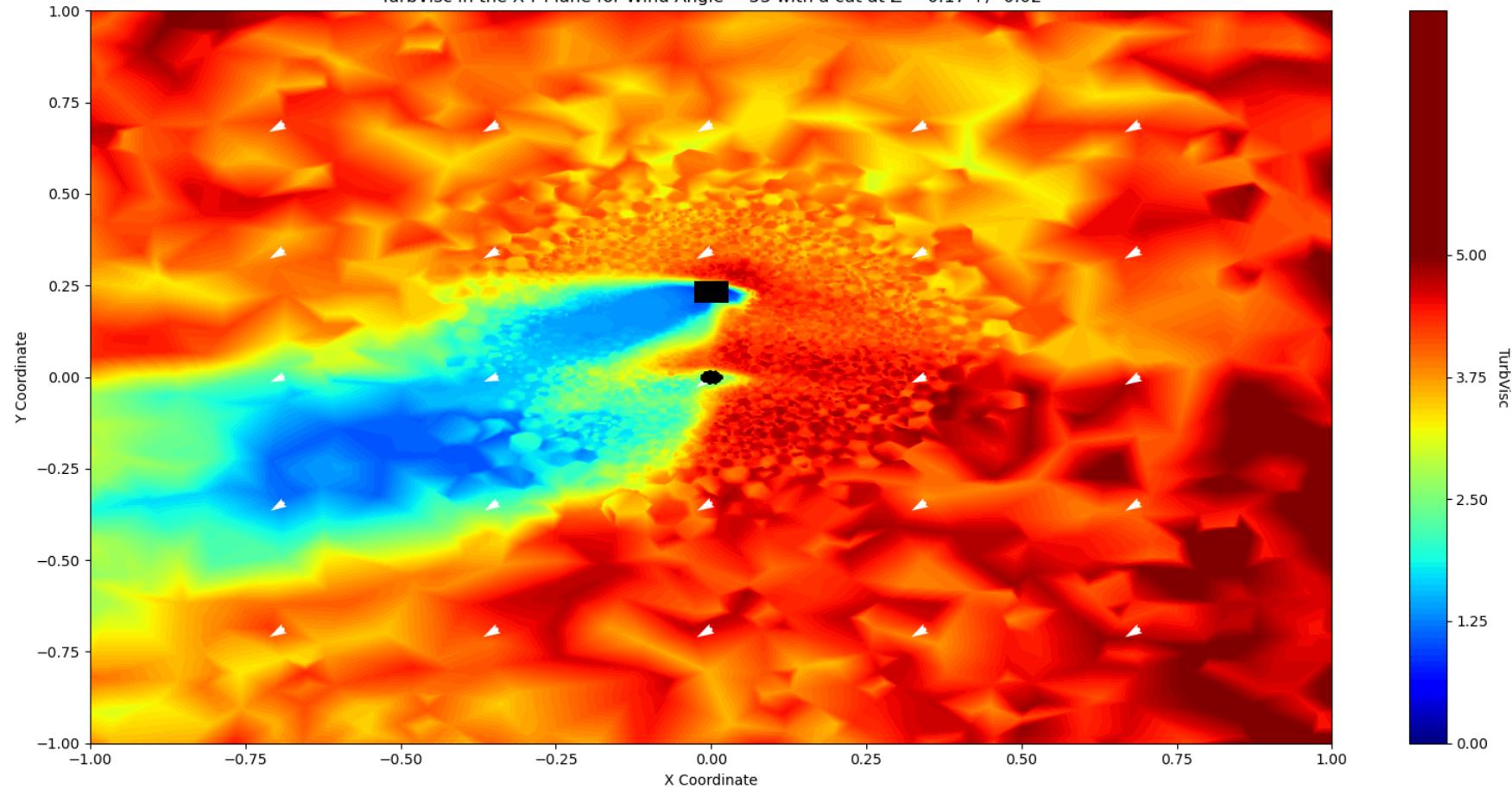
TurbVisc in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



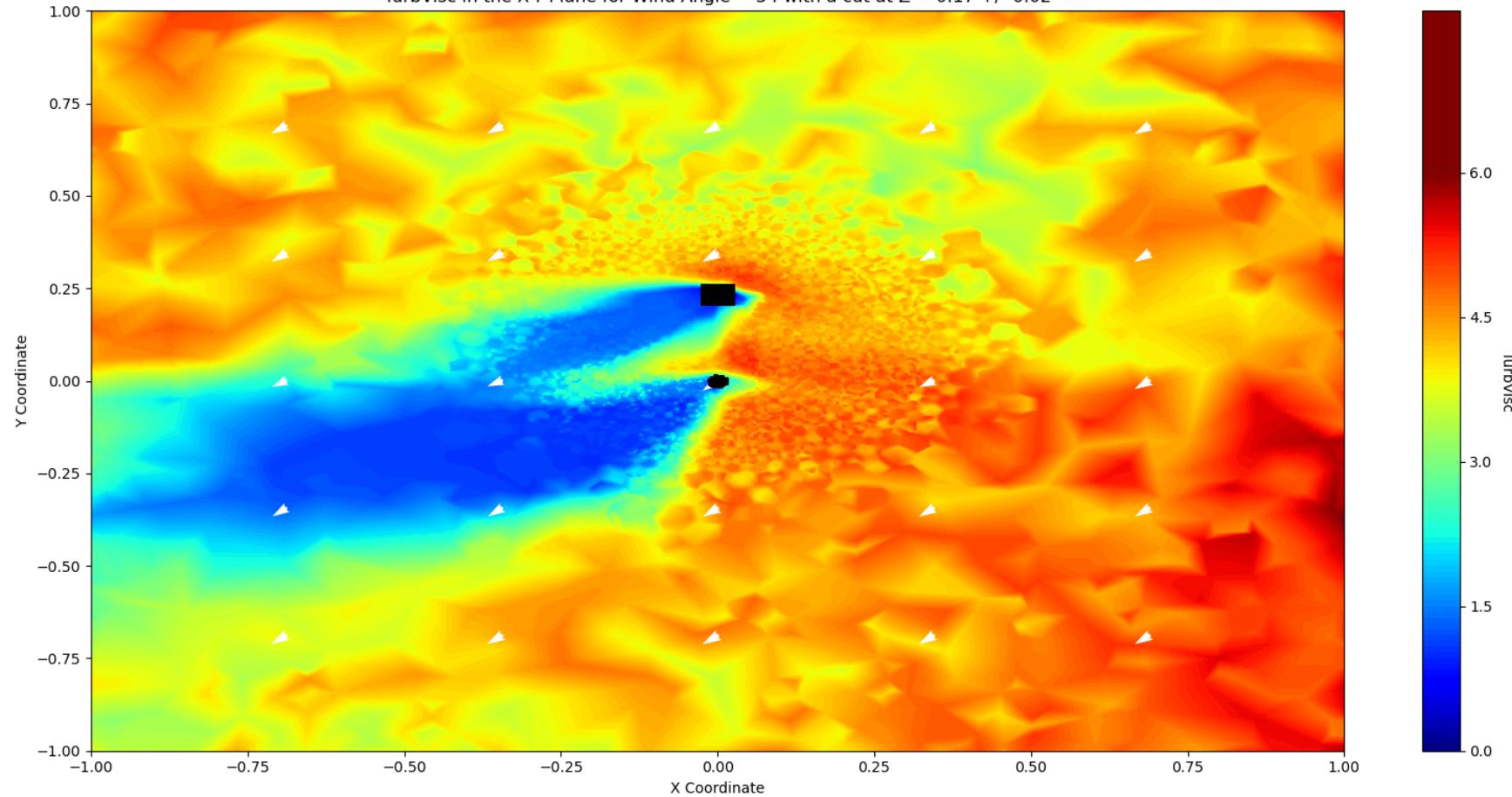
TurbVisc in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



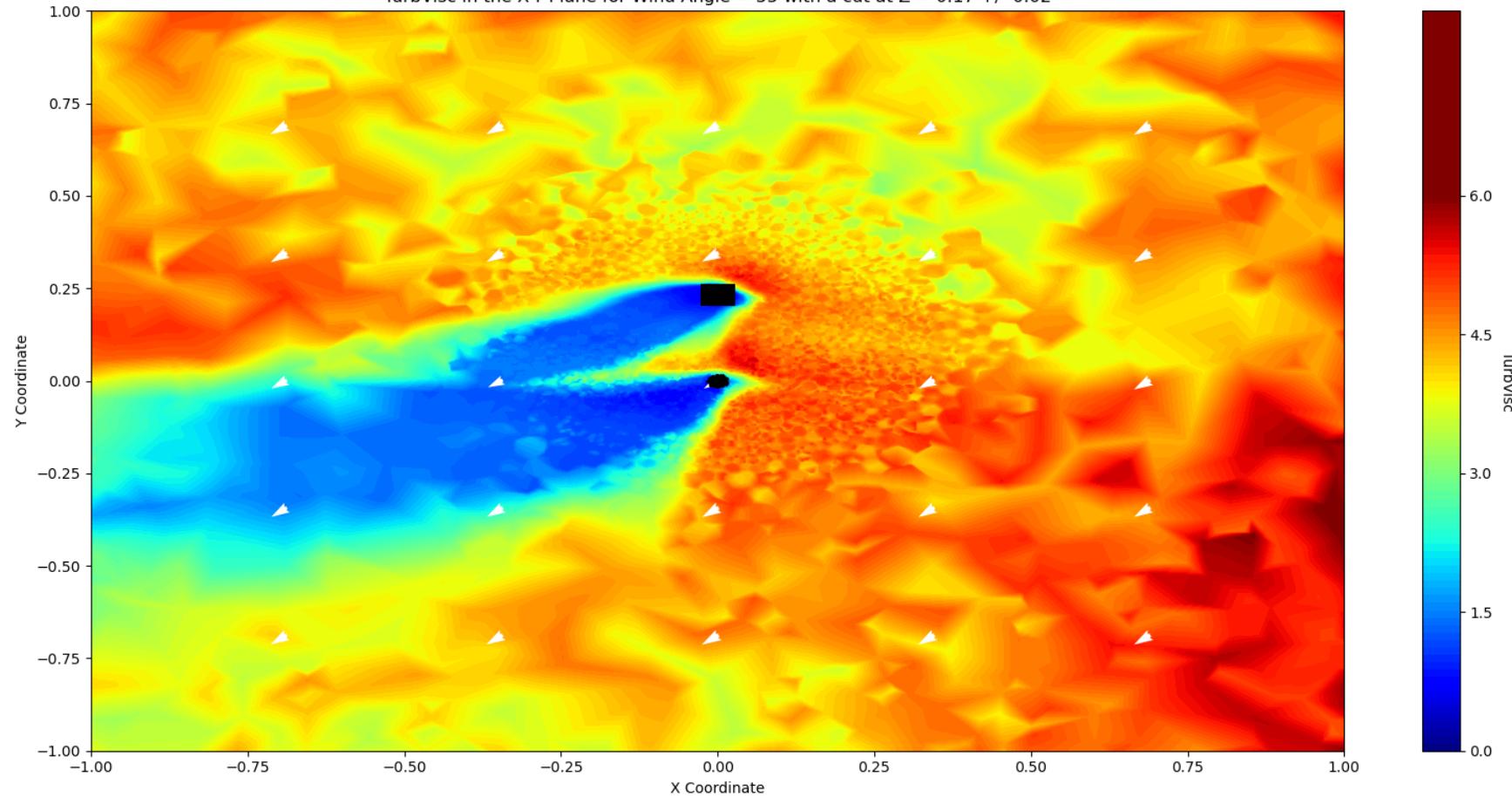
TurbVisc in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



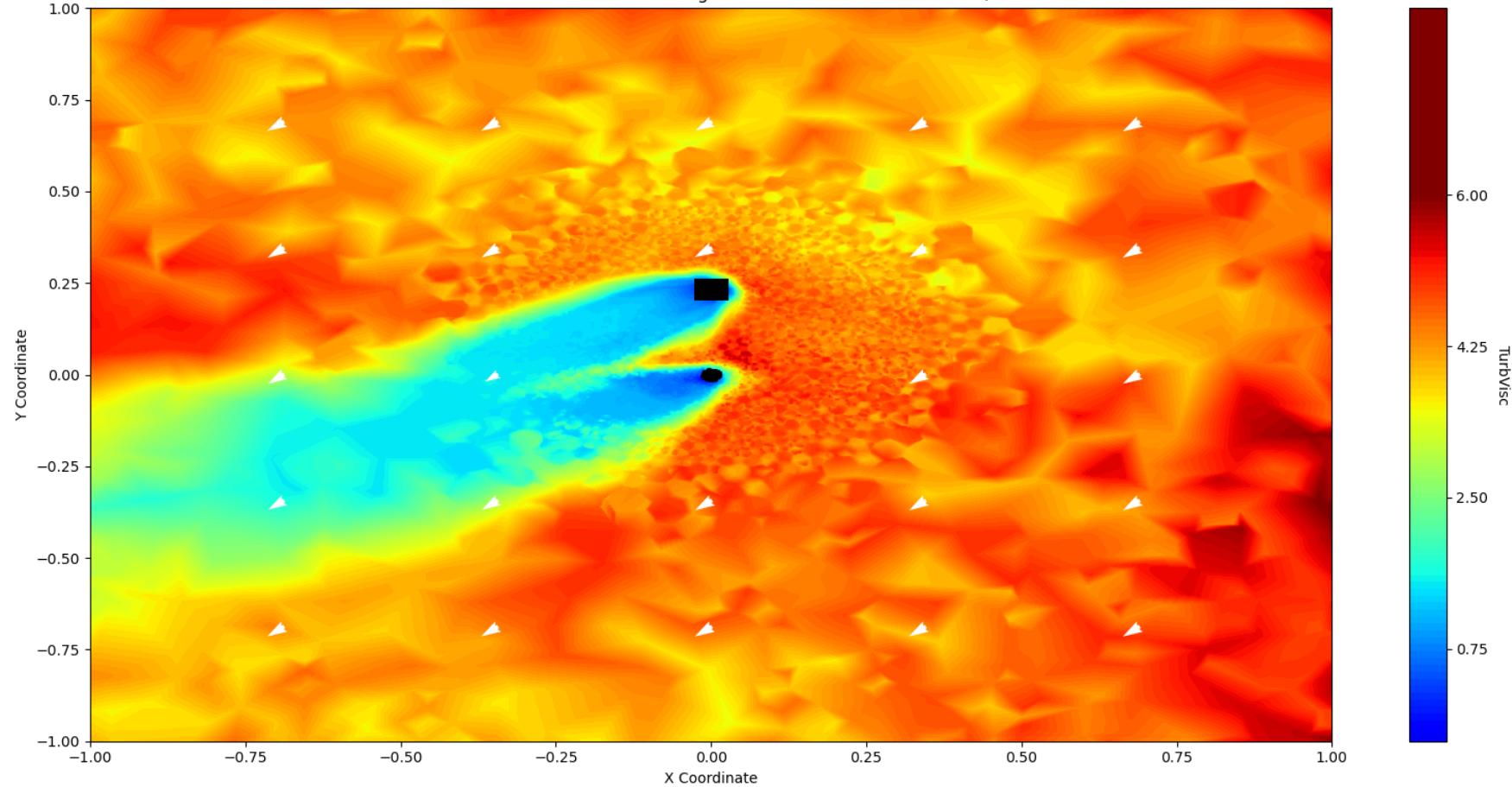
TurbVisc in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



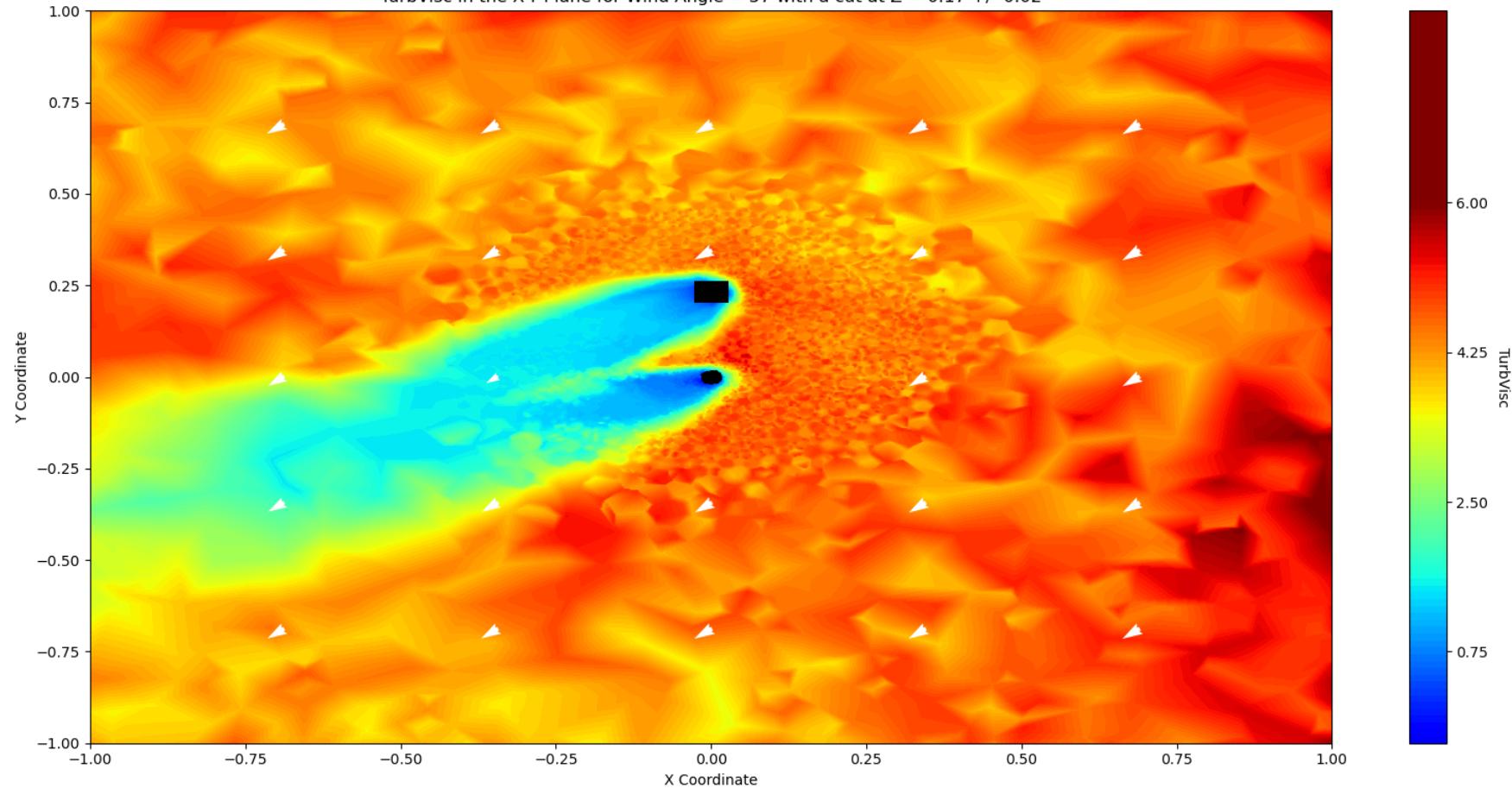
TurbVisc in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



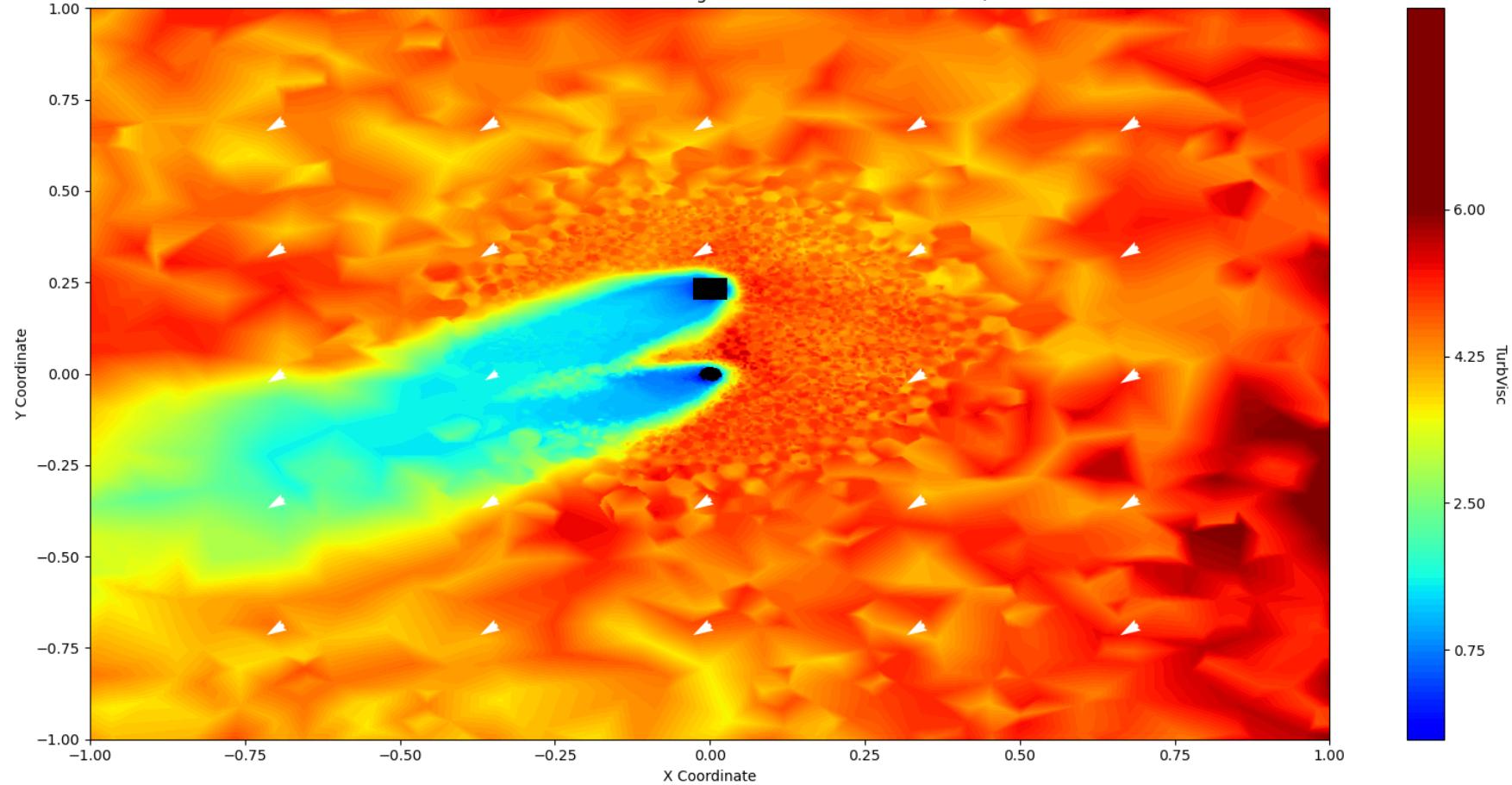
TurbVisc in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



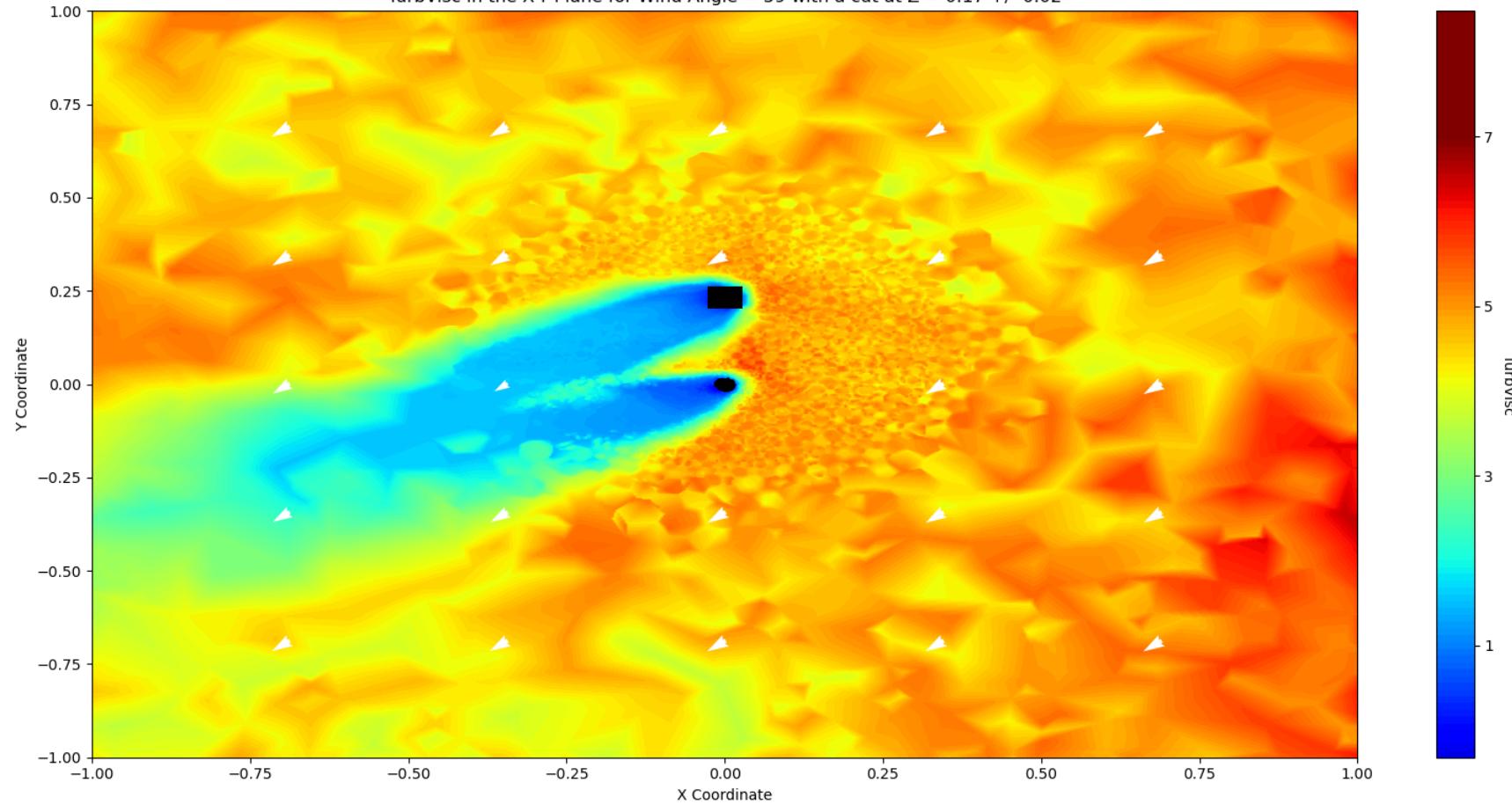
TurbVisc in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



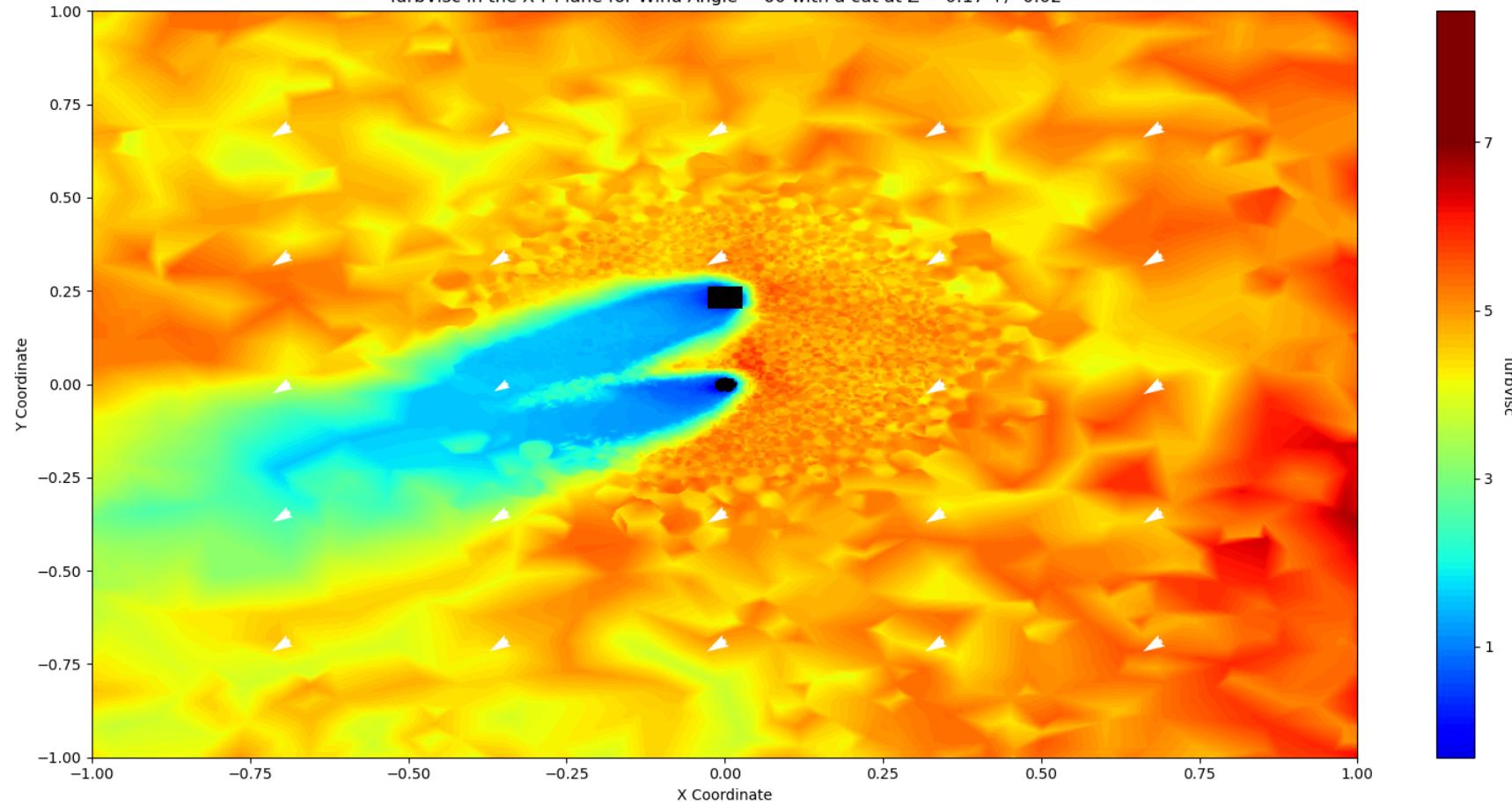
TurbVisc in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



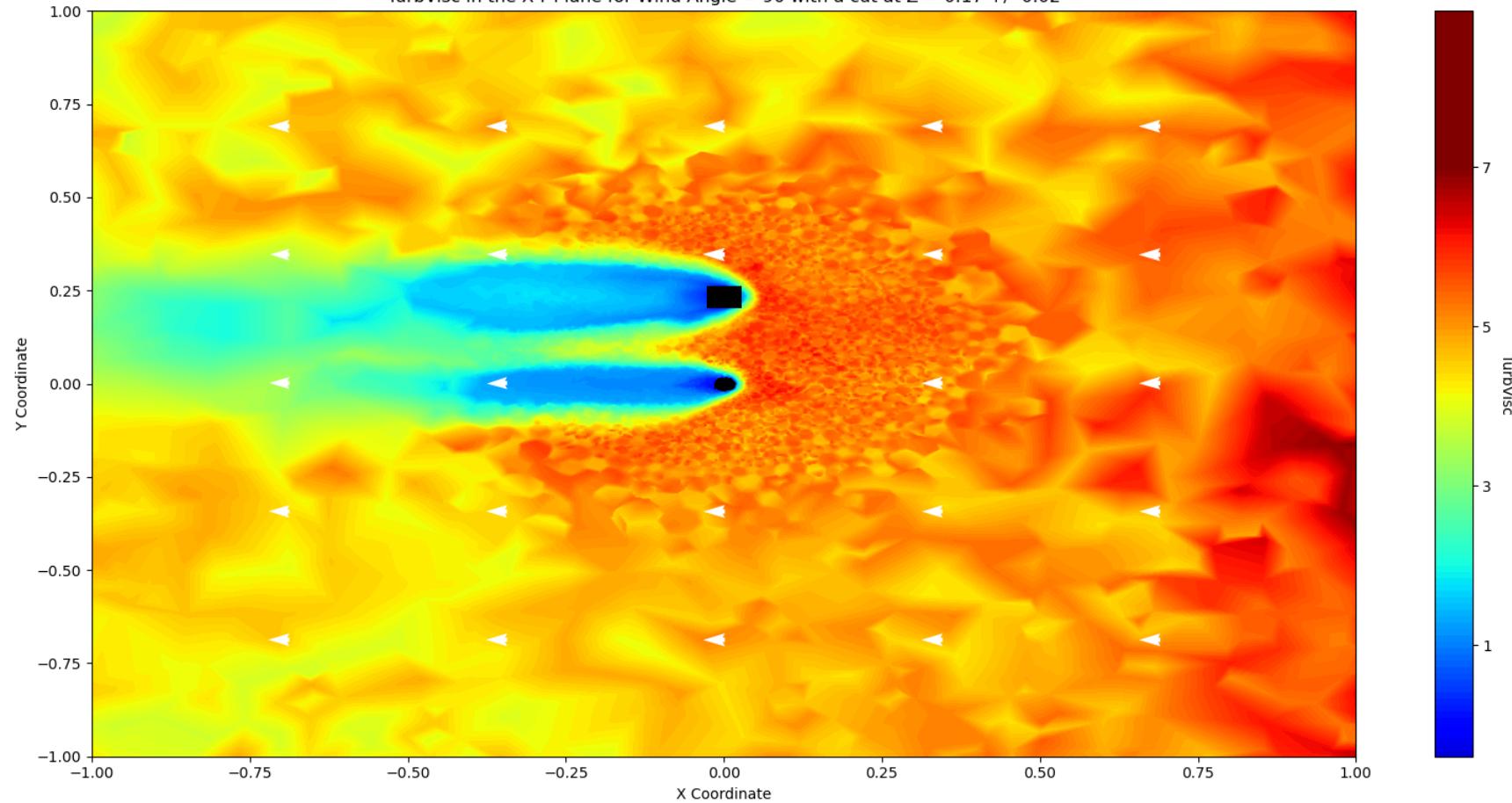
TurbVisc in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



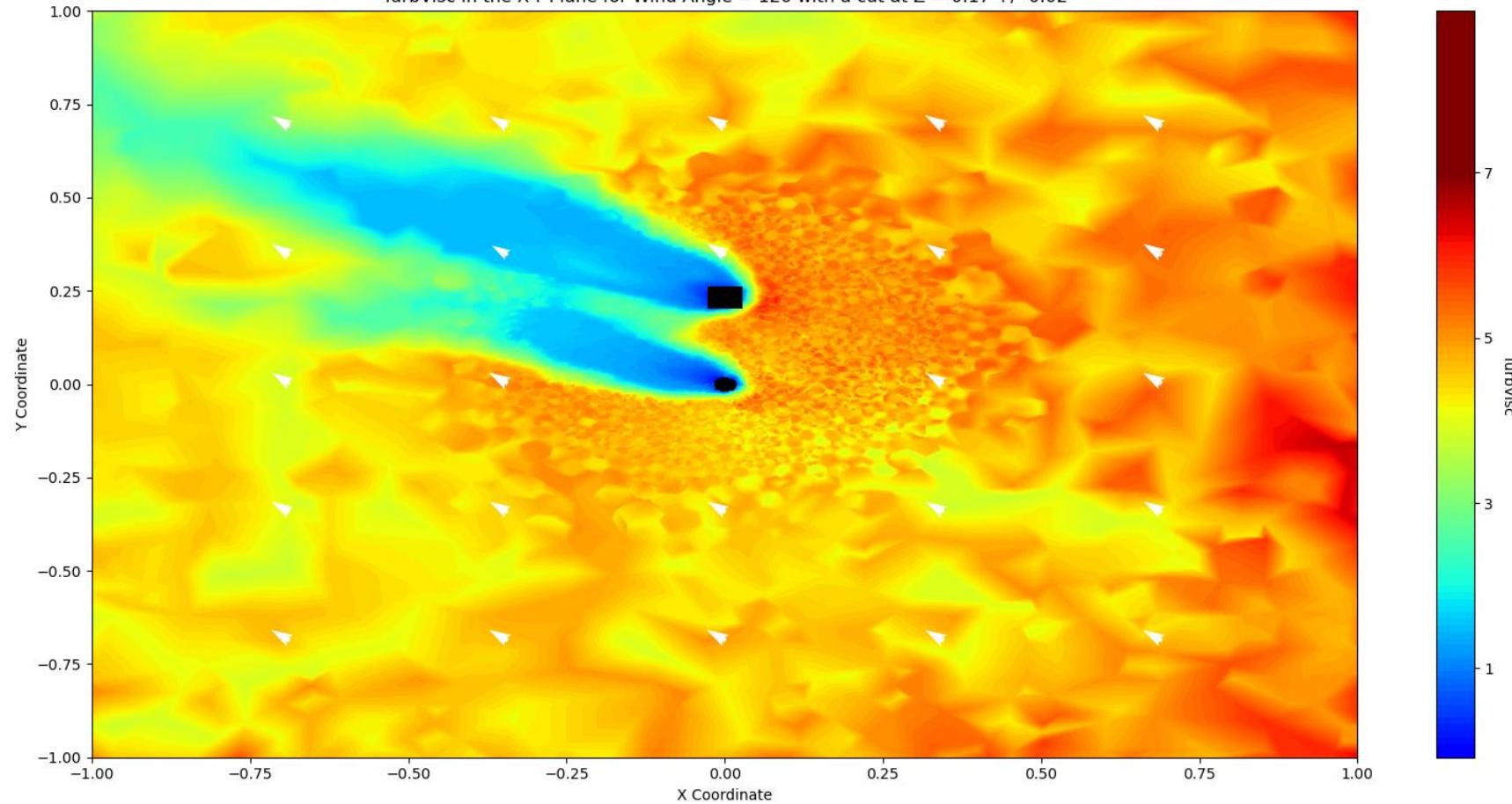
TurbVisc in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



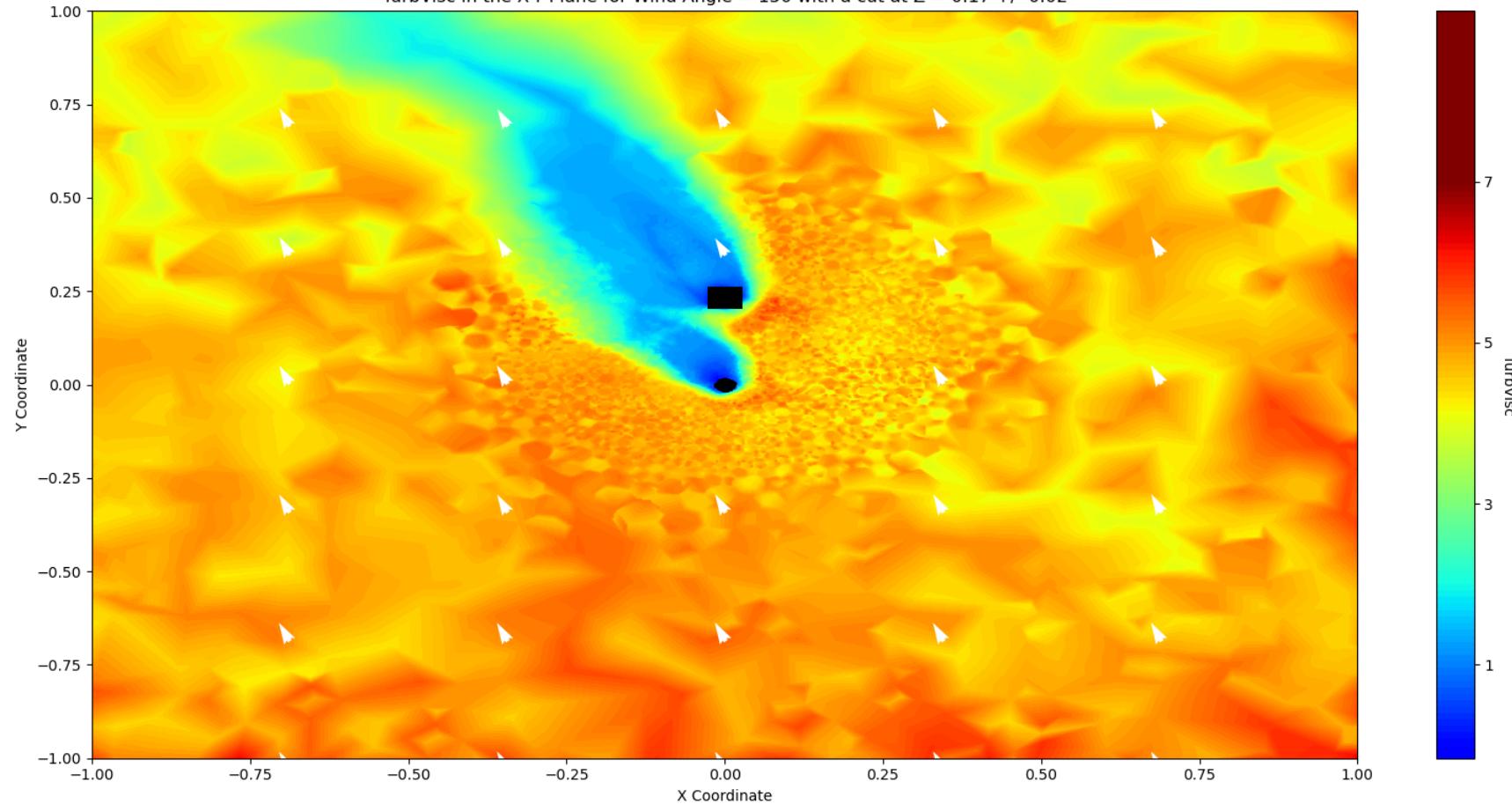
TurbVisc in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



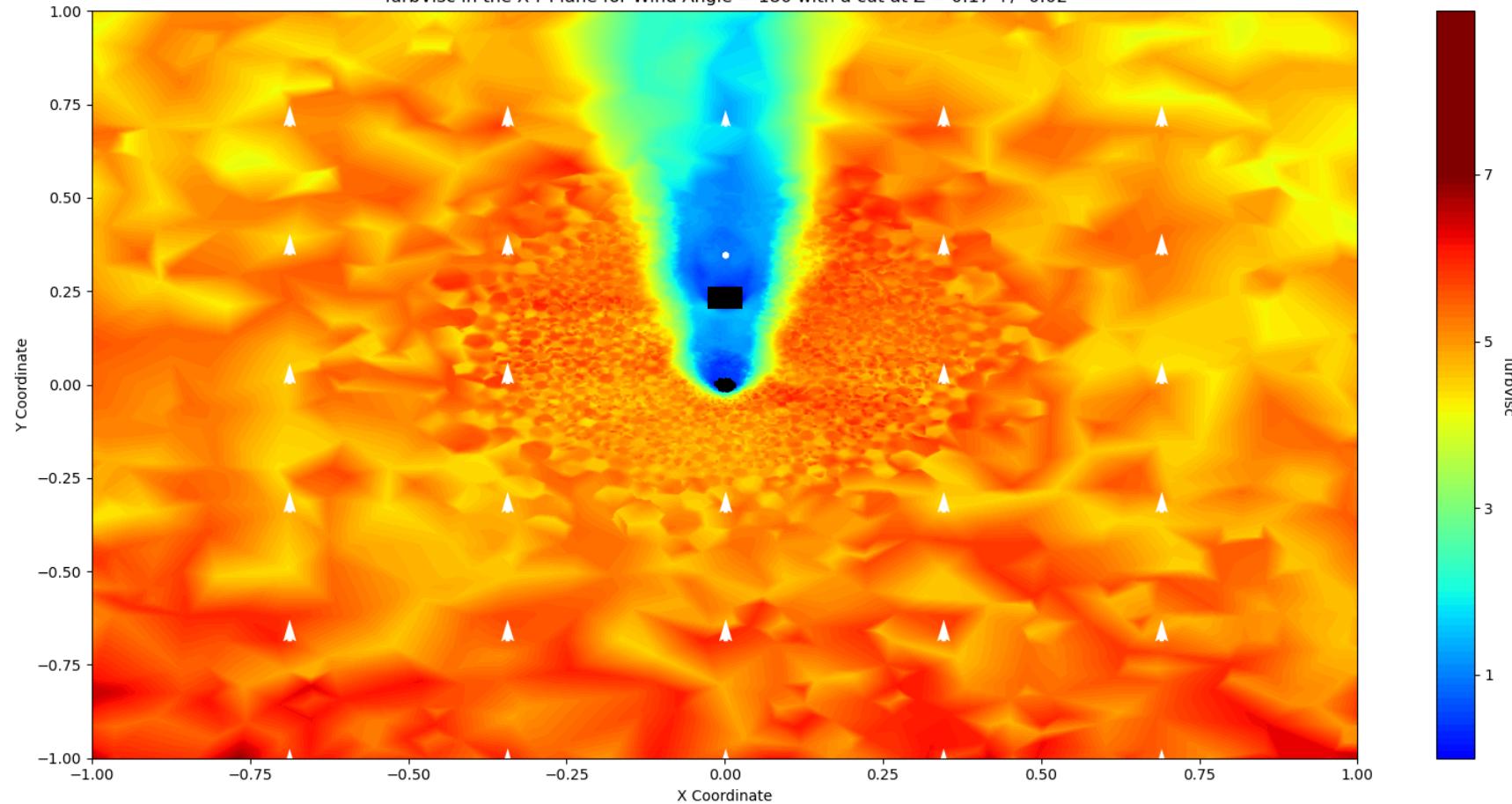
TurbVisc in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



Progress so far - Data Loss + Cont Loss
(with Boundary Conditions imposed)
(Adam Optimizer)

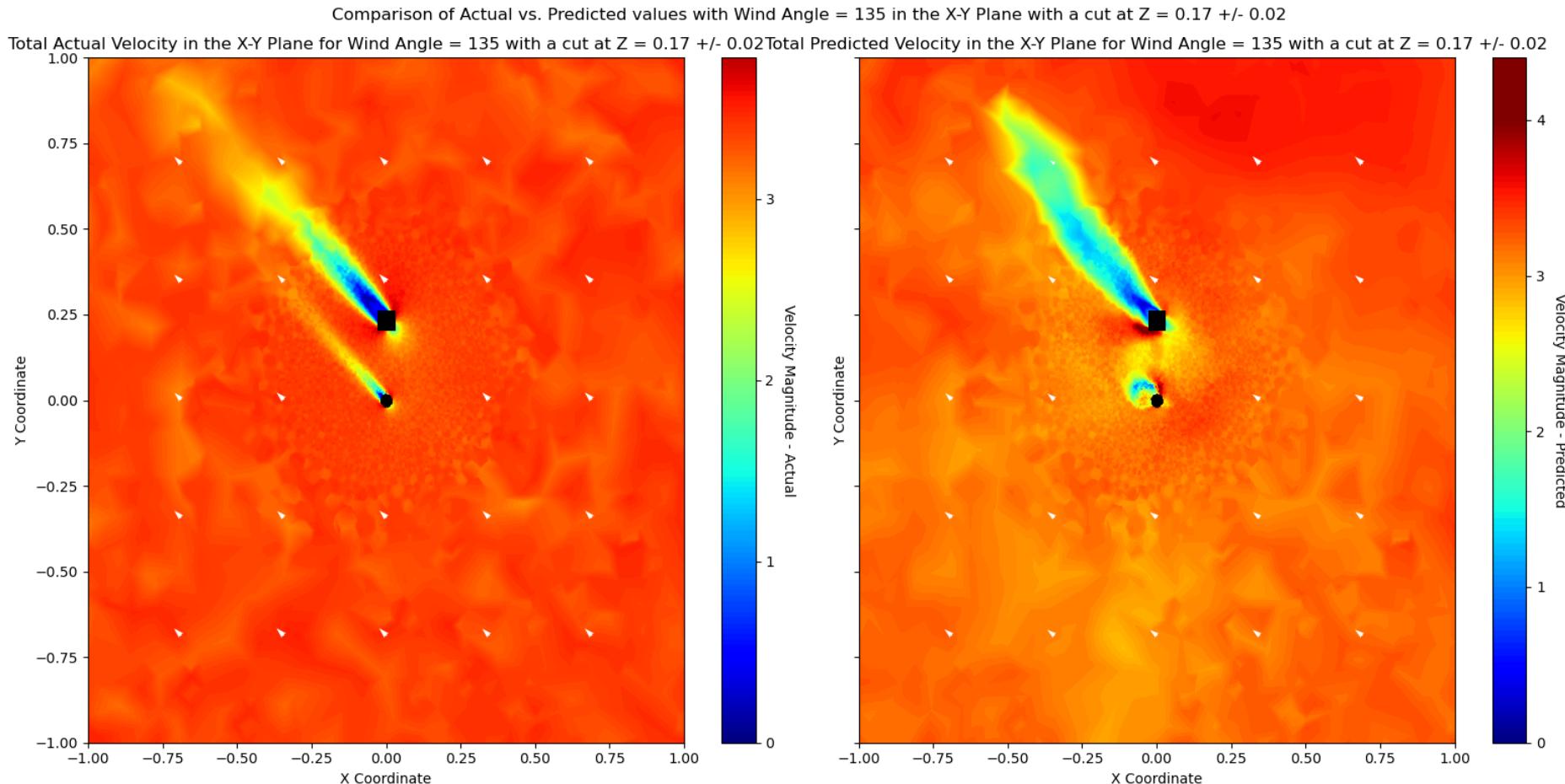
Threshold = 1E-5 (2595 Epochs, not completed), GPU Workstation

Scripts v3 – PREDICTING (135 DEG)

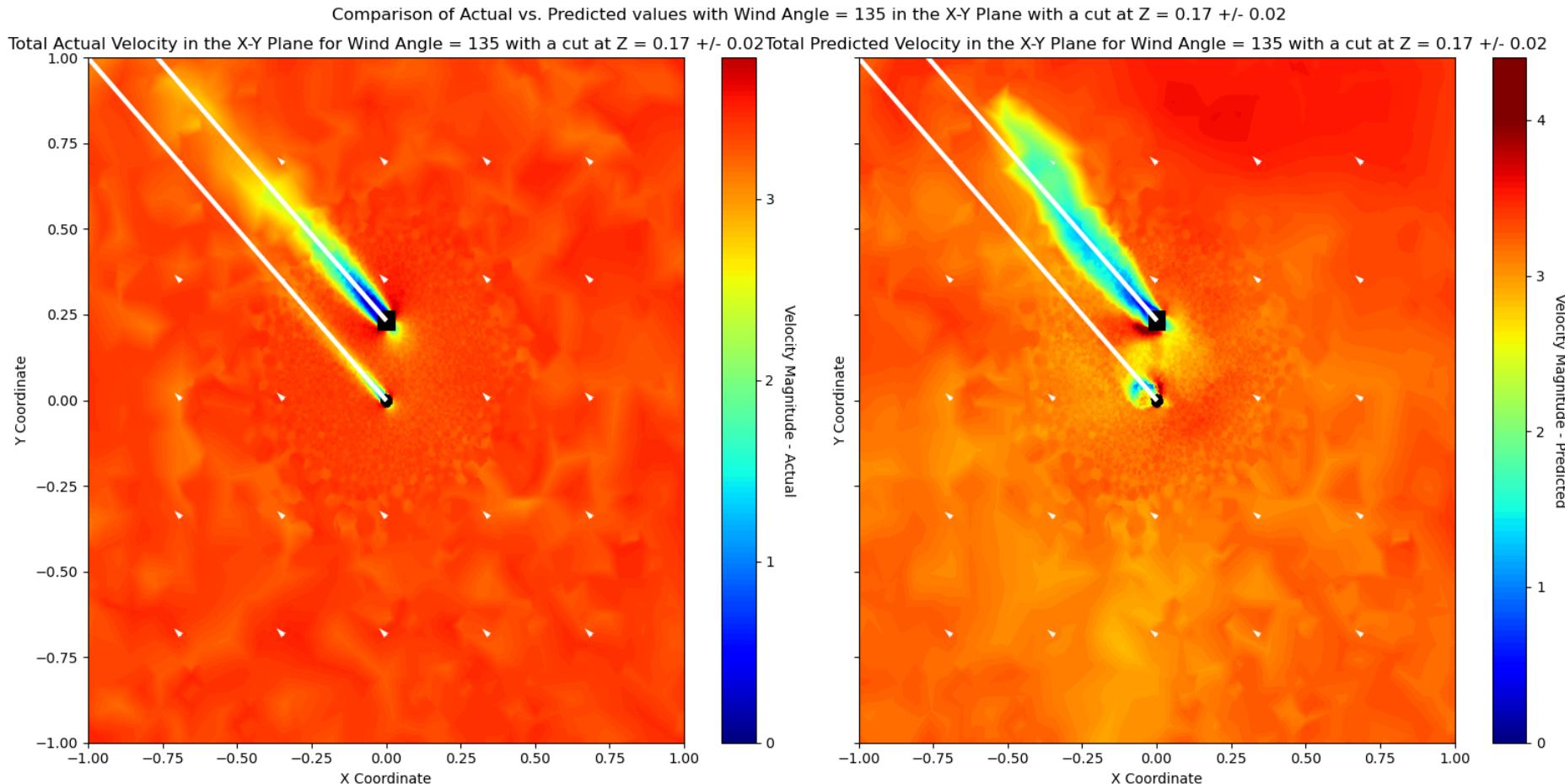
Progress so far - Data + Cont + Boundary Loss (Adam Optimizer)
Threshold = 1E-5 (2595 Epochs, so far...), GPU Workstation
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	2.34936	1.532762	0.771956	-0.38986
Velocity:0	0.144433	0.380043	0.231045	0.858292
Velocity:1	0.249833	0.499833	0.391981	0.757216
Velocity:2	0.011697	0.108153	0.052498	0.642446
TurbVisc	2.276149	1.508691	1.100187	0.983414

Progress so far - Data + Cont + Boundary Loss (Adam Optimizer), Threshold = 1E-5 (2595 Epochs, so far...), GPU Workstation
Predicting Results - X-Y Total Velocity Plot (Angle = 135)

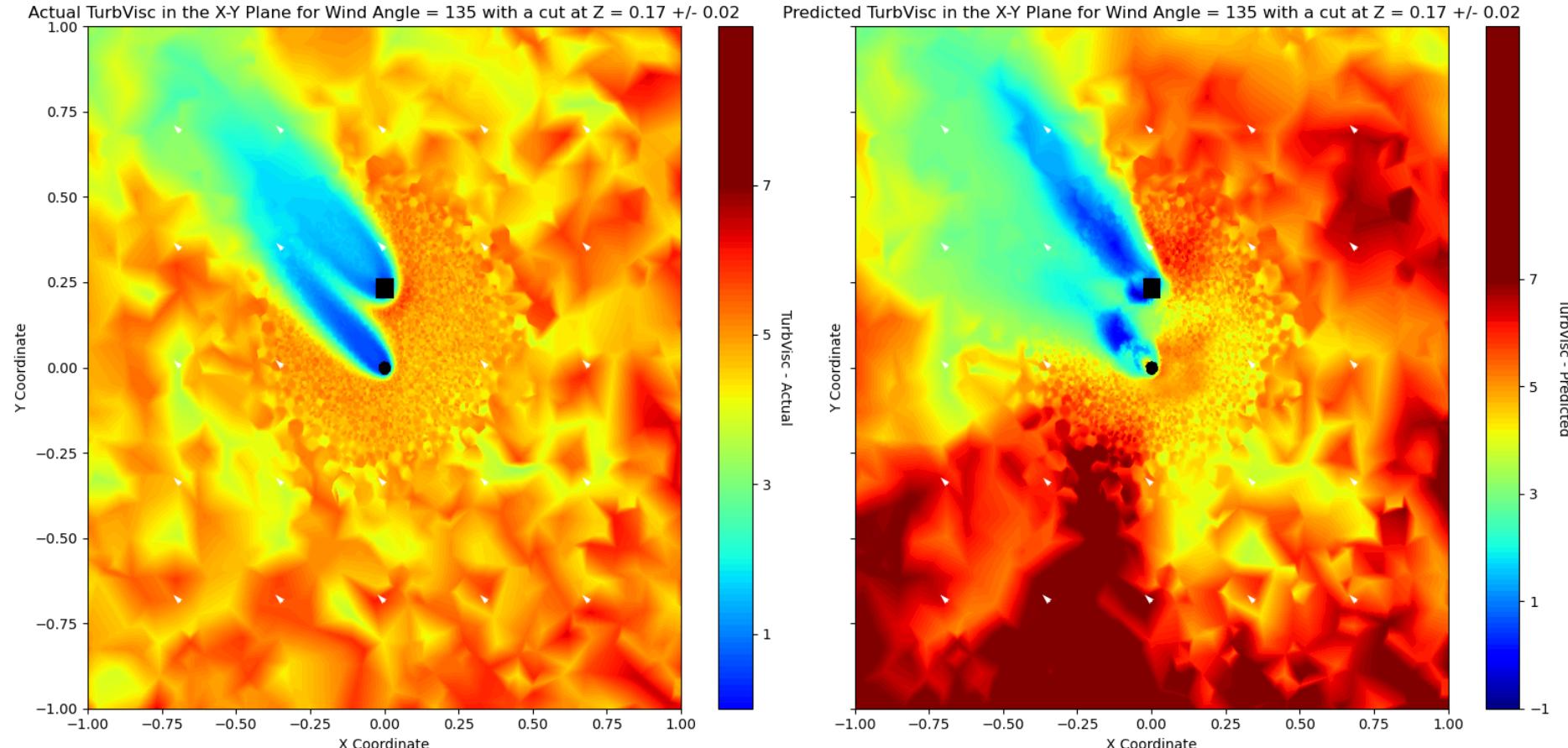


Progress so far - Data + Cont + Boundary Loss (Adam Optimizer), Threshold = 1E-5 (2595 Epochs, so far...), GPU Workstation
Predicting Results - X-Y Total Velocity Plot (Angle = 135)



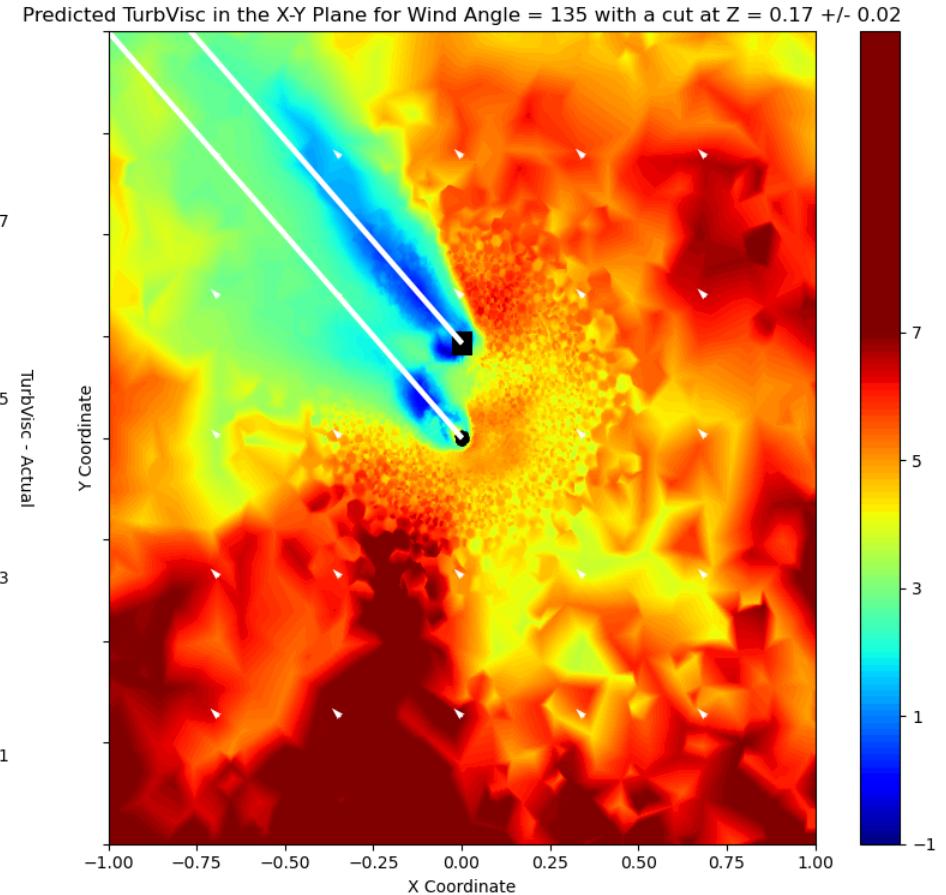
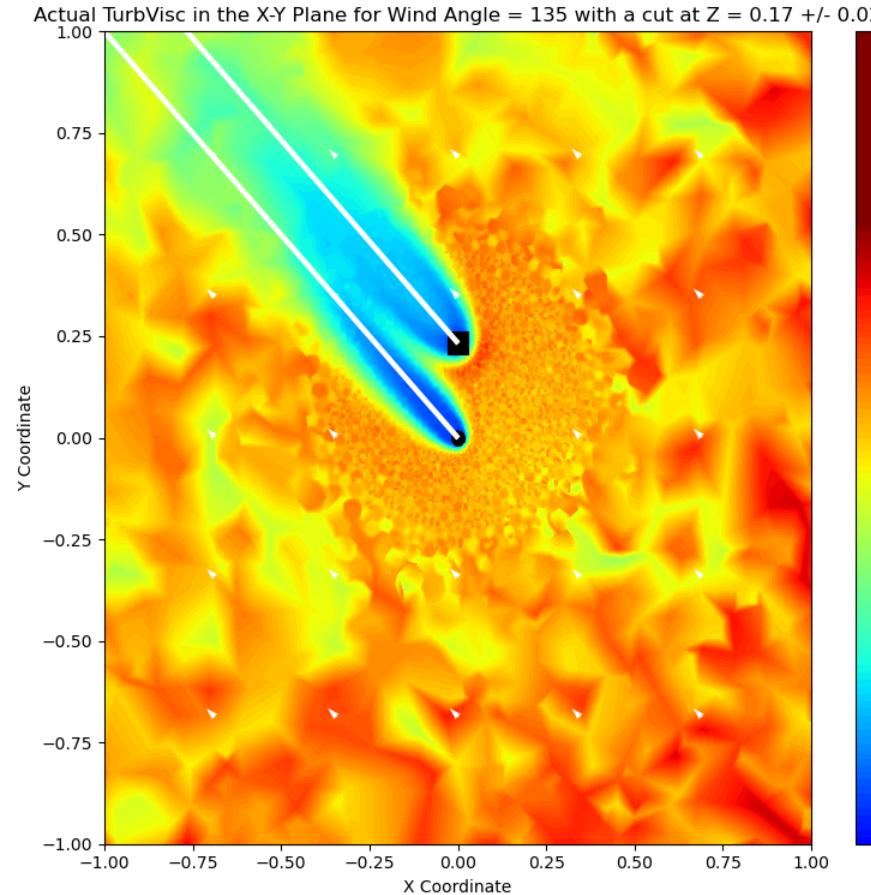
Progress so far - Data + Cont + Boundary Loss (Adam Optimizer), Threshold = 1E-5 (2595 Epochs, so far...), GPU Workstation
Predicting Results - X-Y TurbVisc Plot (Angle = 135)

Comparison of Actual vs. Predicted values with Wind Angle = 135 in the X-Y Plane with a cut at Z = 0.17 +/- 0.02



Progress so far - Data + Cont + Boundary Loss (Adam Optimizer), Threshold = 1E-5 (2595 Epochs, so far...), GPU Workstation
Predicting Results - X-Y TurbVisc Plot (Angle = 135)

Comparison of Actual vs. Predicted values with Wind Angle = 135 in the X-Y Plane with a cut at Z = 0.17 +/- 0.02

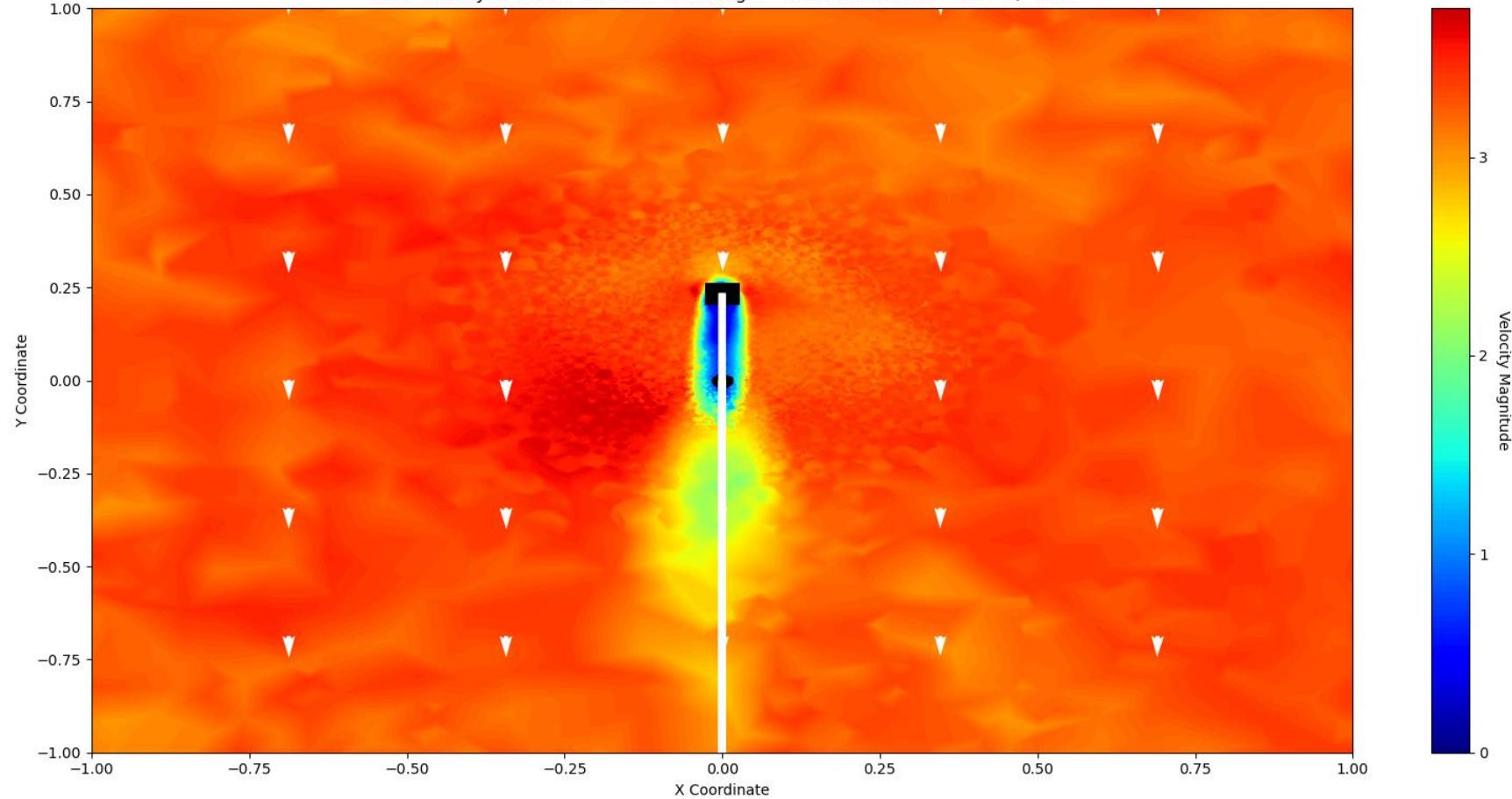


Progress so far - Data Loss + Cont Loss
(with Boundary Conditions imposed)
(Adam Optimizer)

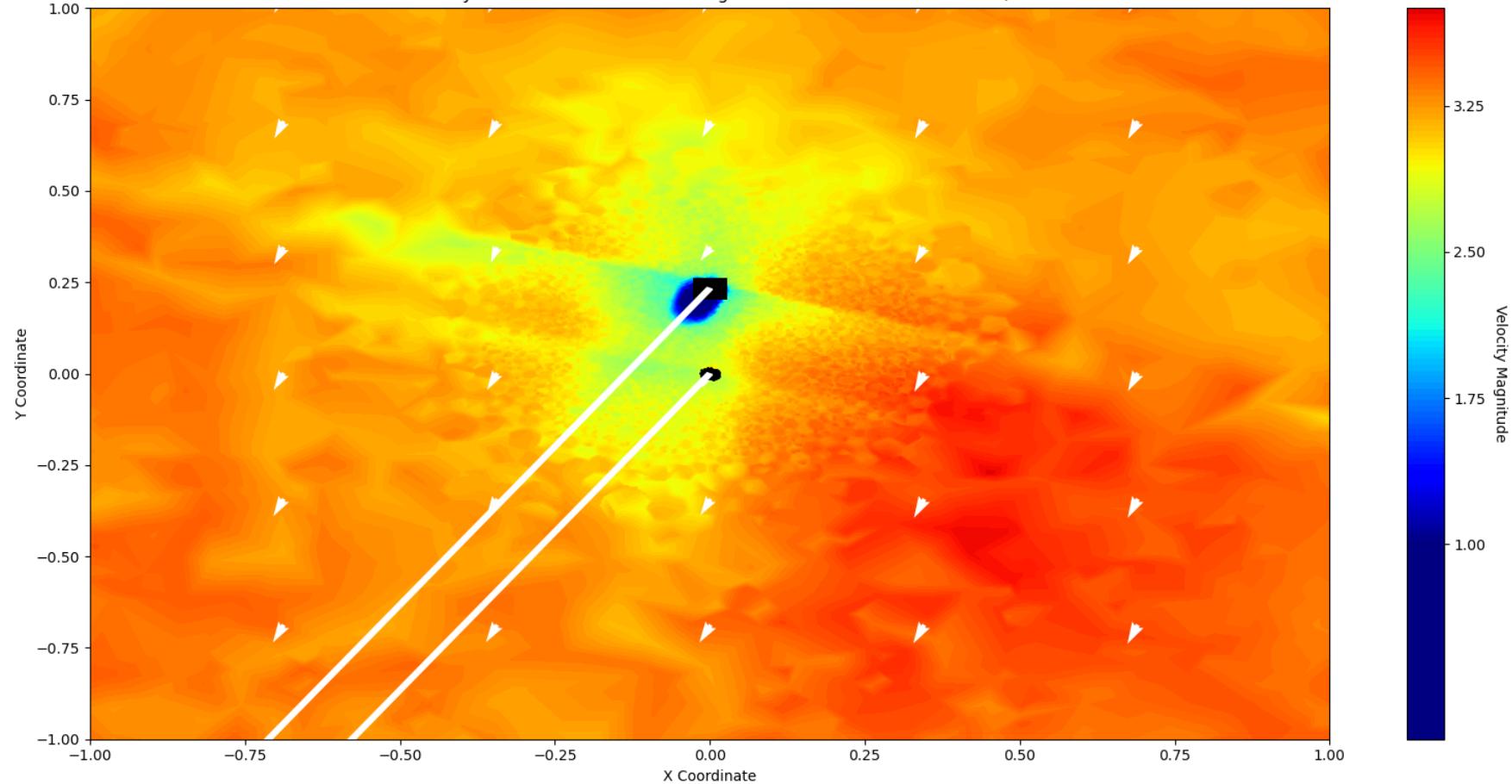
Threshold = 1E-5 (2595 Epochs, not completed), GPU Workstation

Scripts v3 – Plotting Any Angle

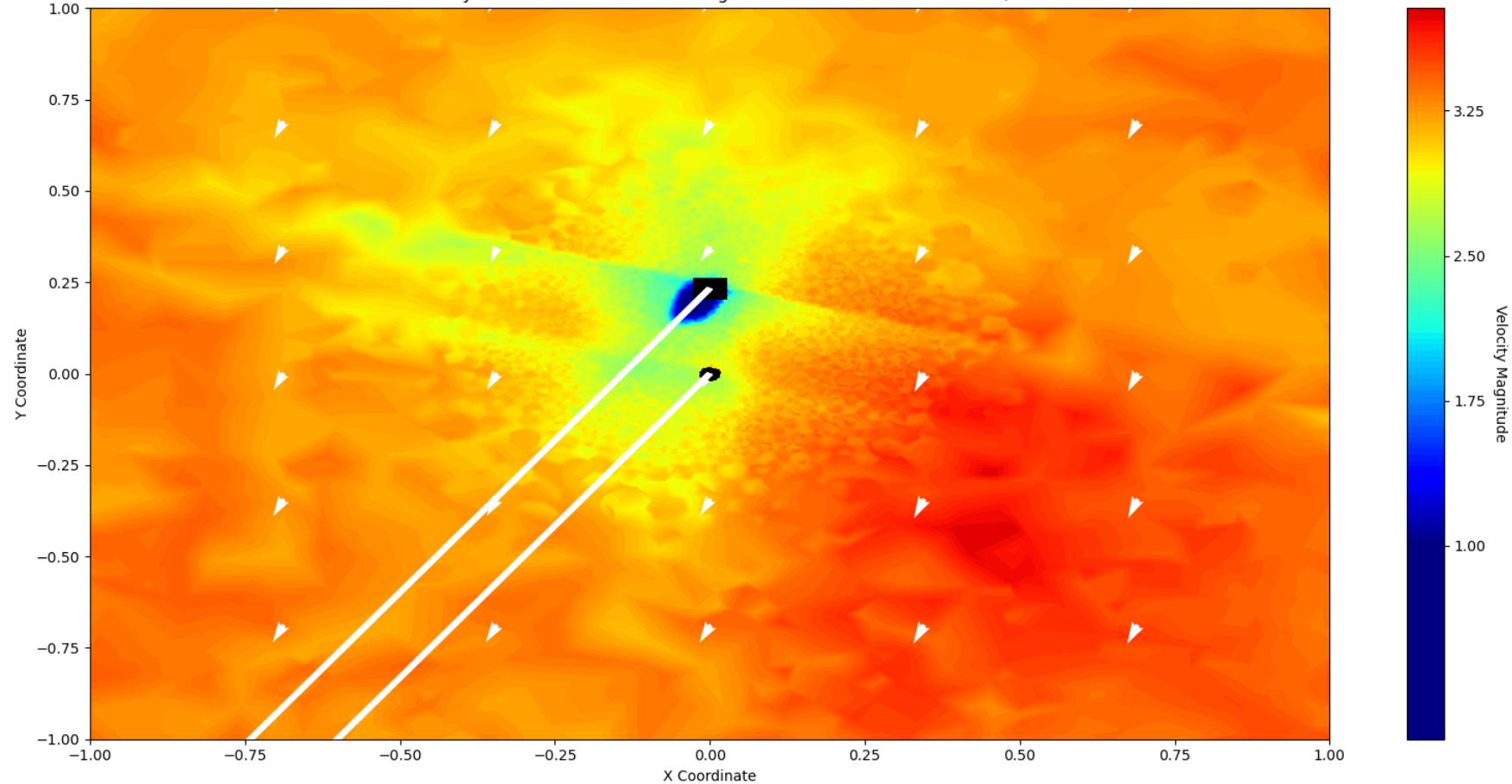
Total Velocity in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



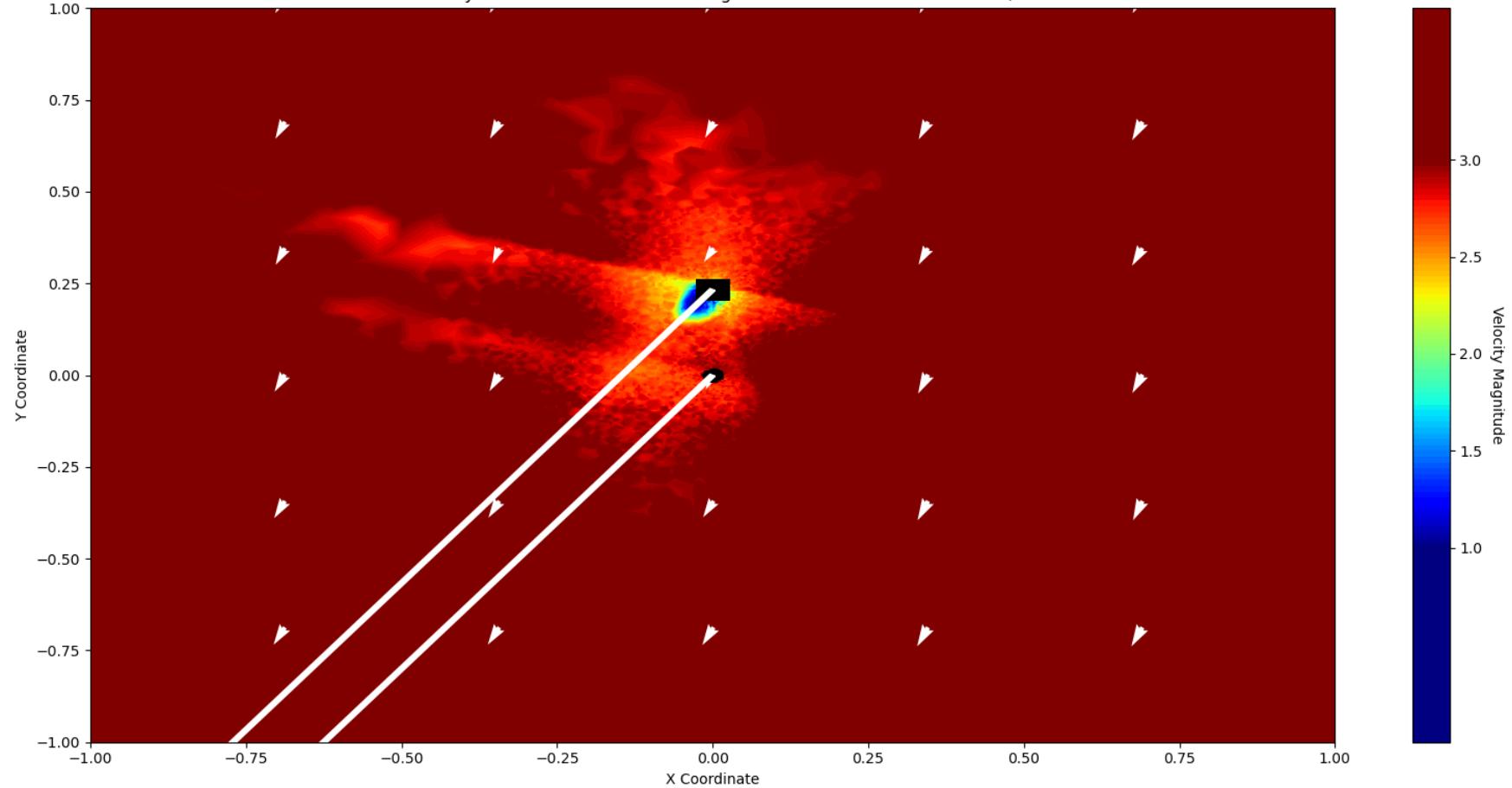
Total Velocity in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



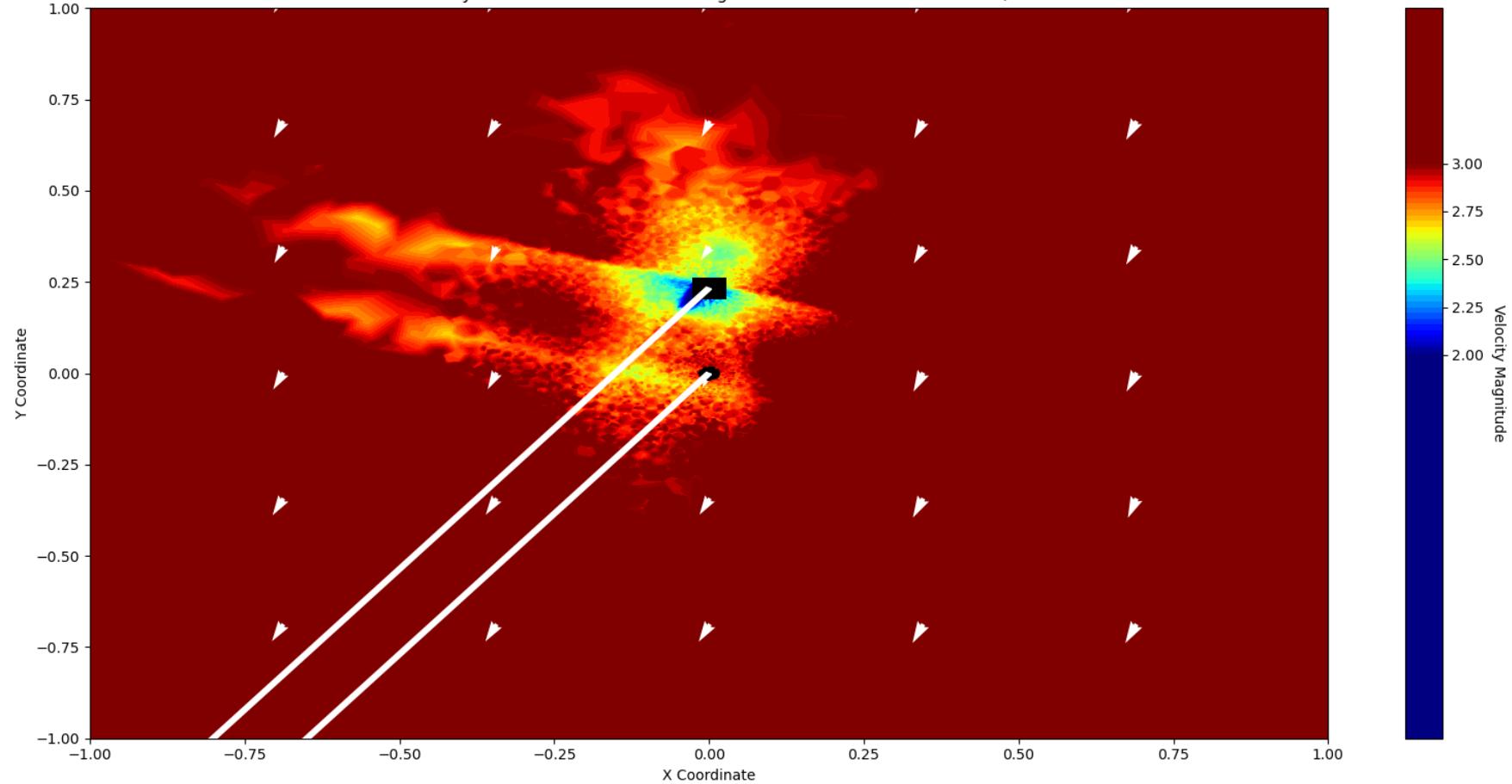
Total Velocity in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



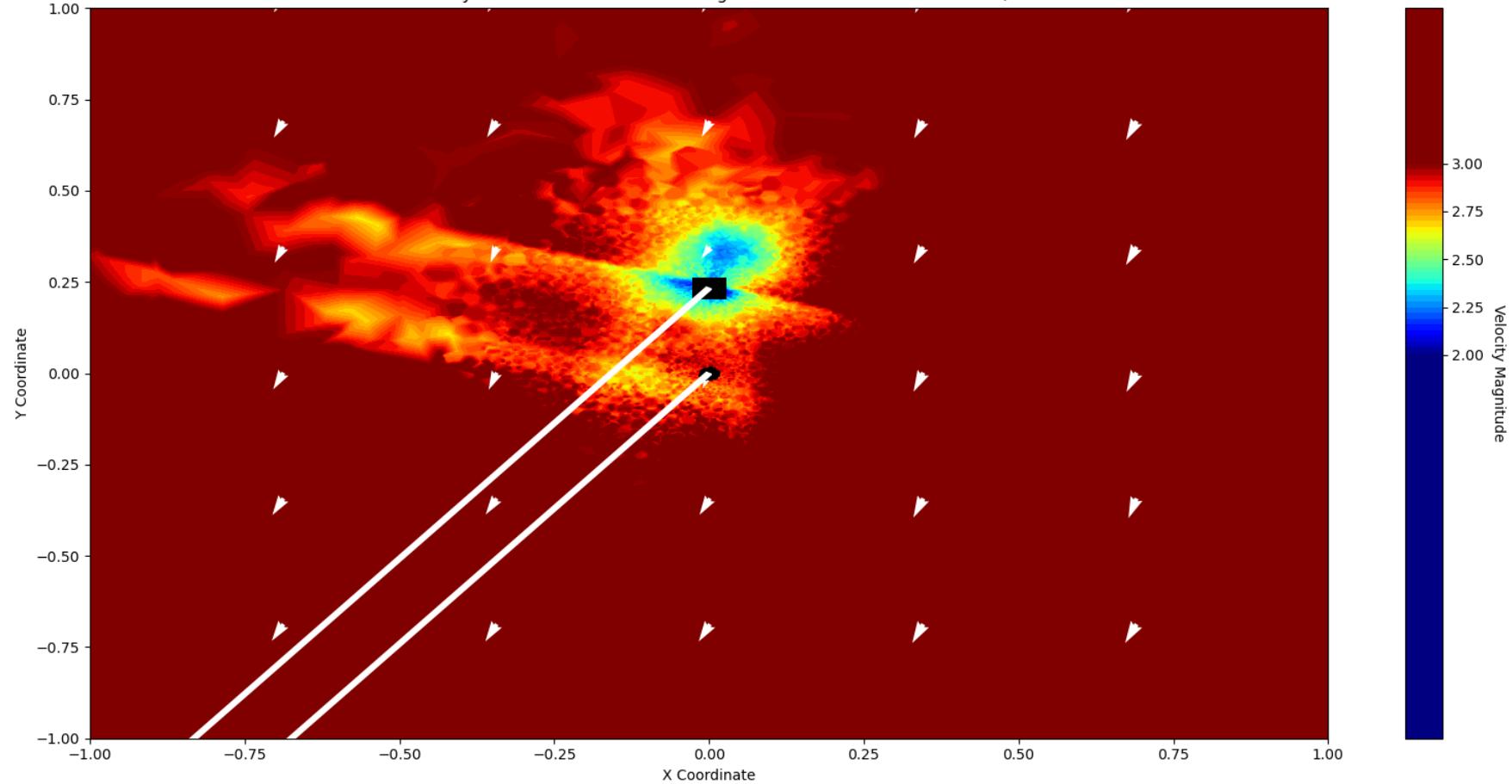
Total Velocity in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



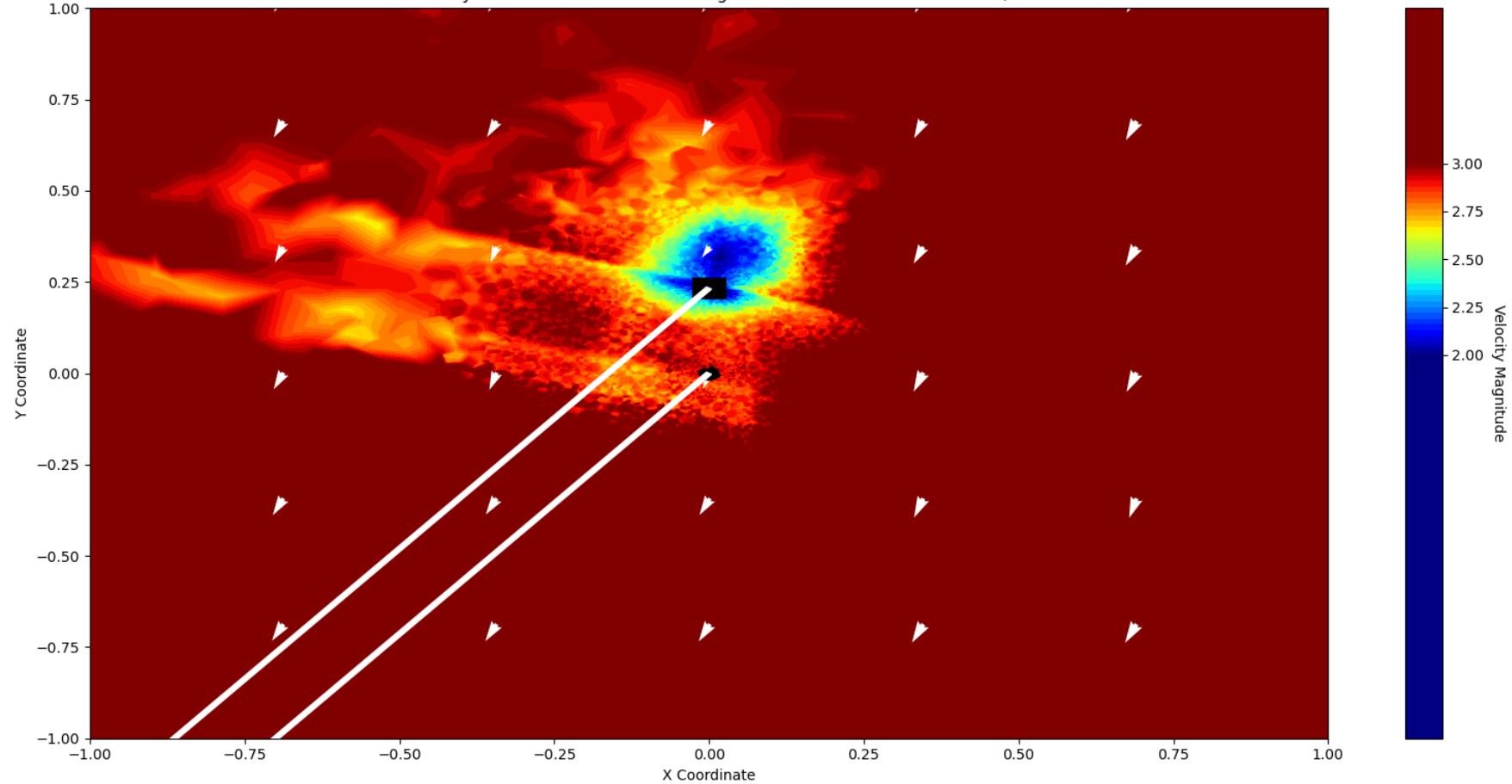
Total Velocity in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



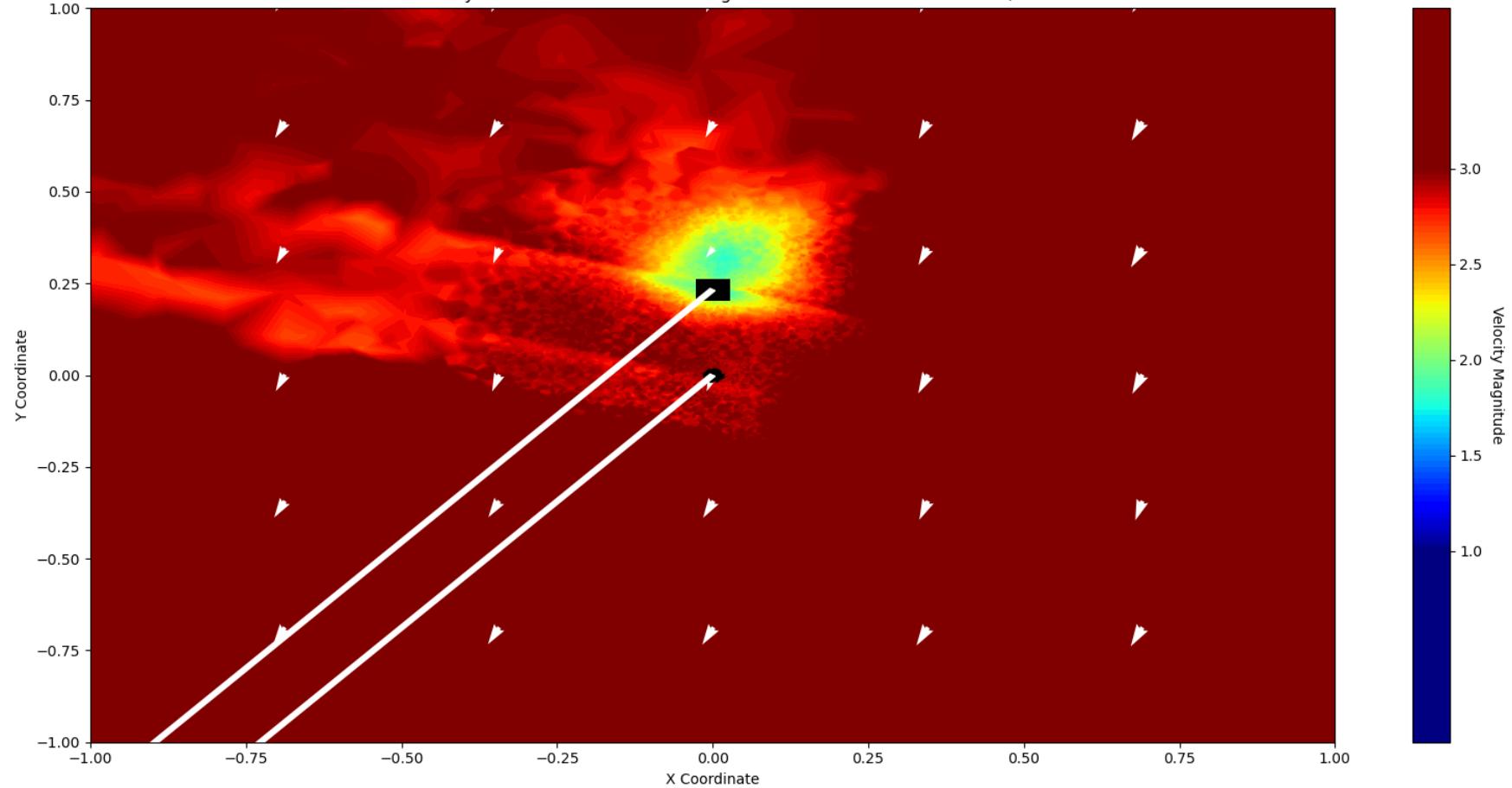
Total Velocity in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



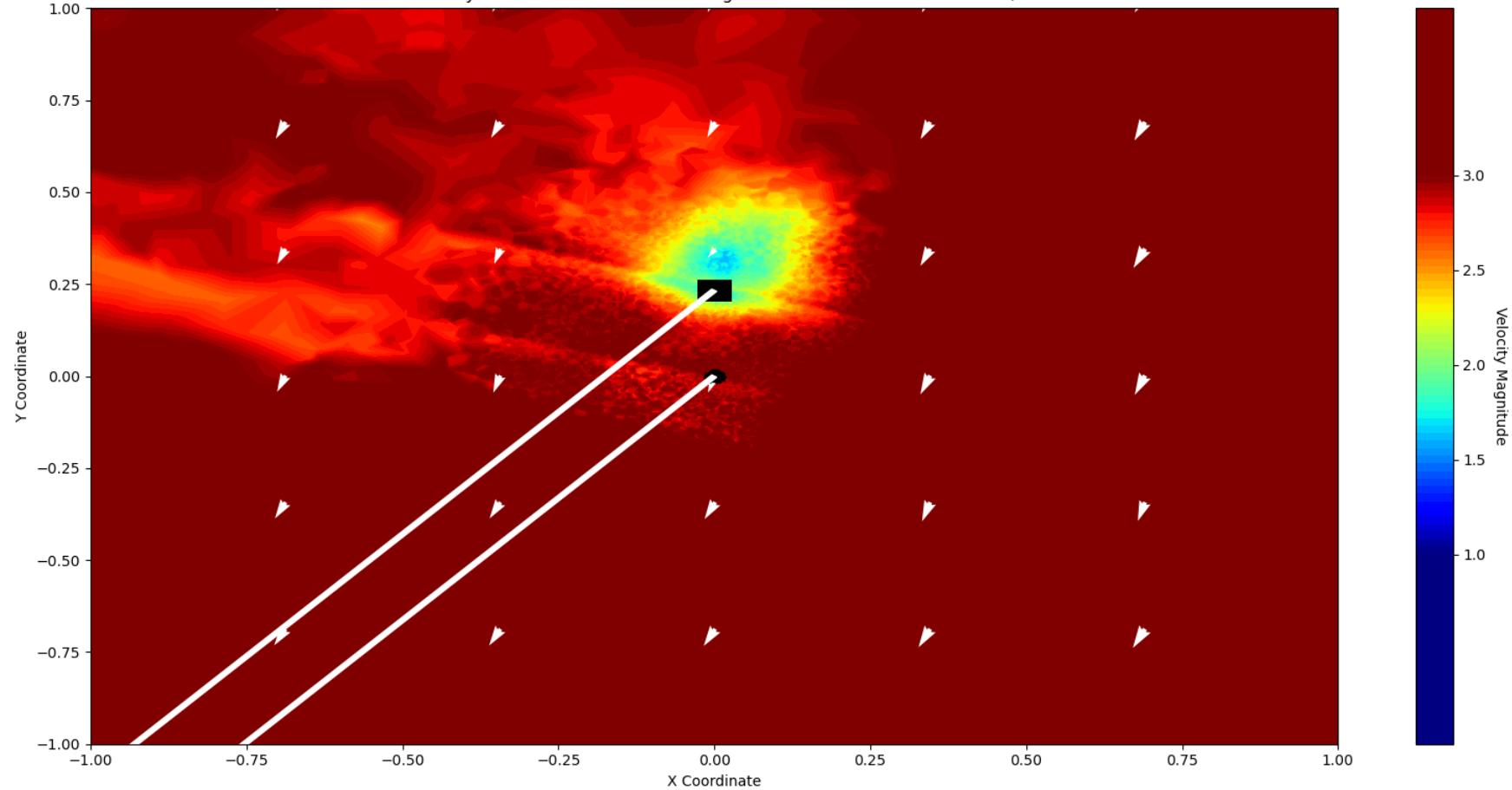
Total Velocity in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



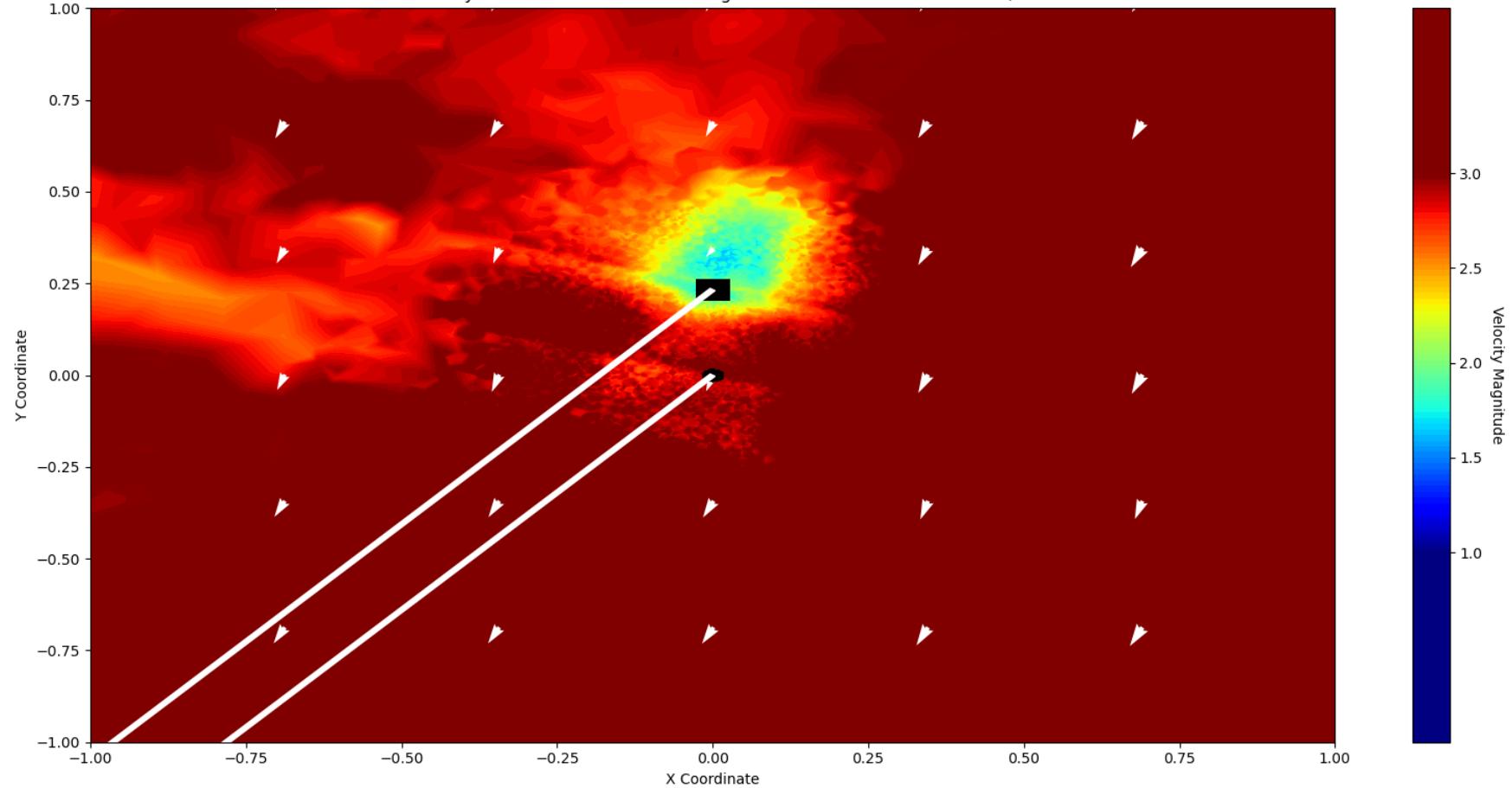
Total Velocity in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



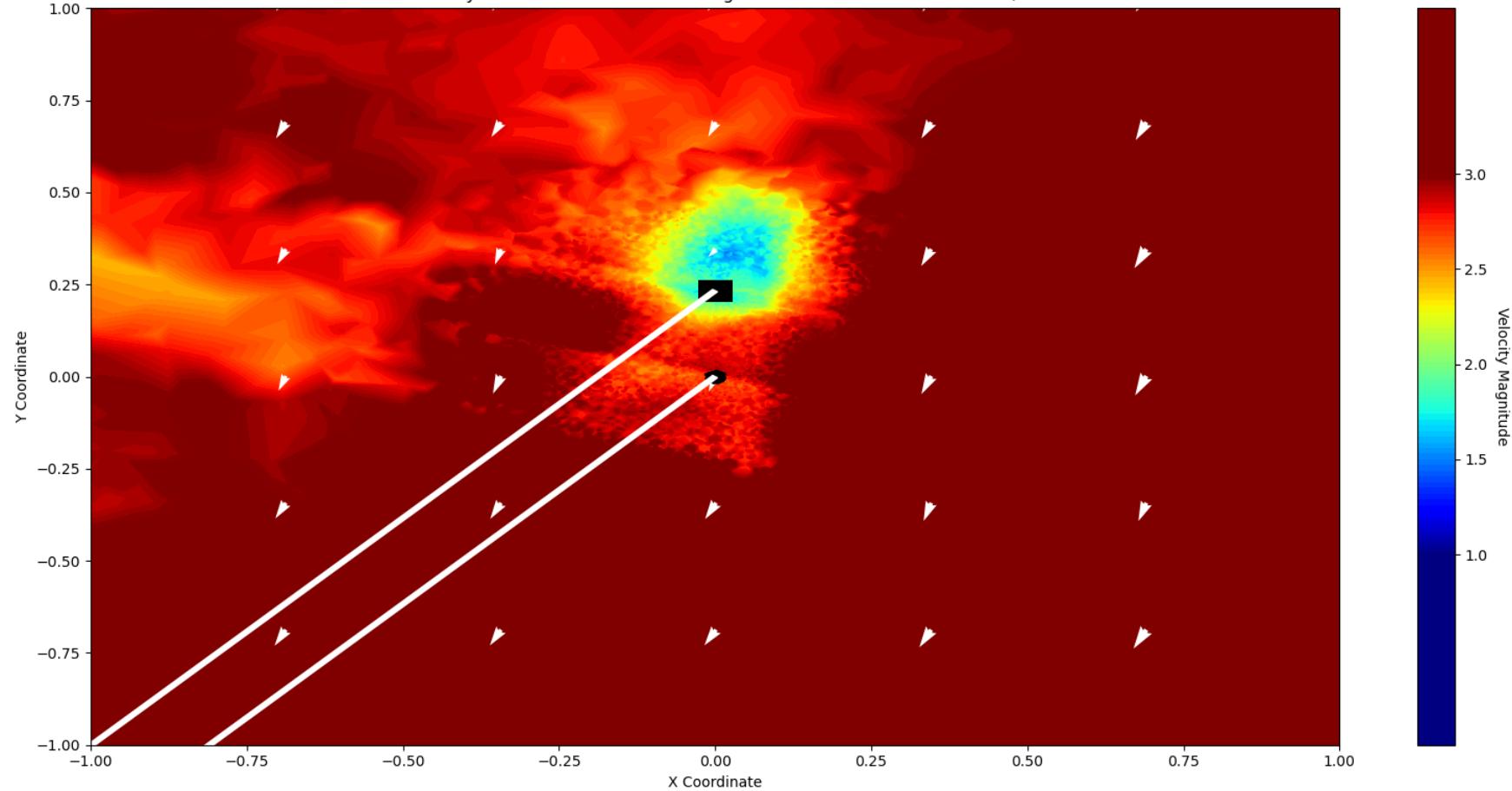
Total Velocity in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



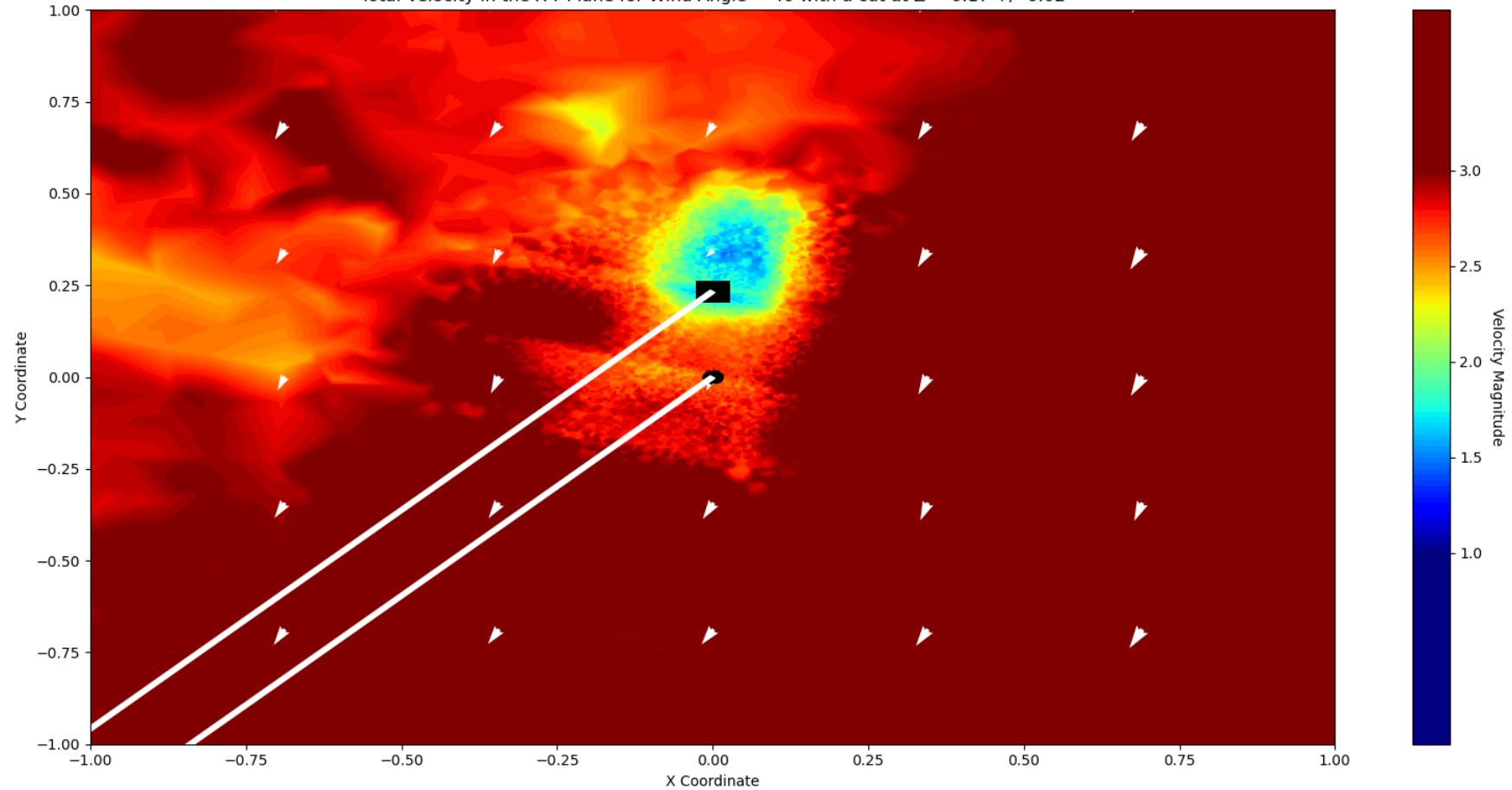
Total Velocity in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



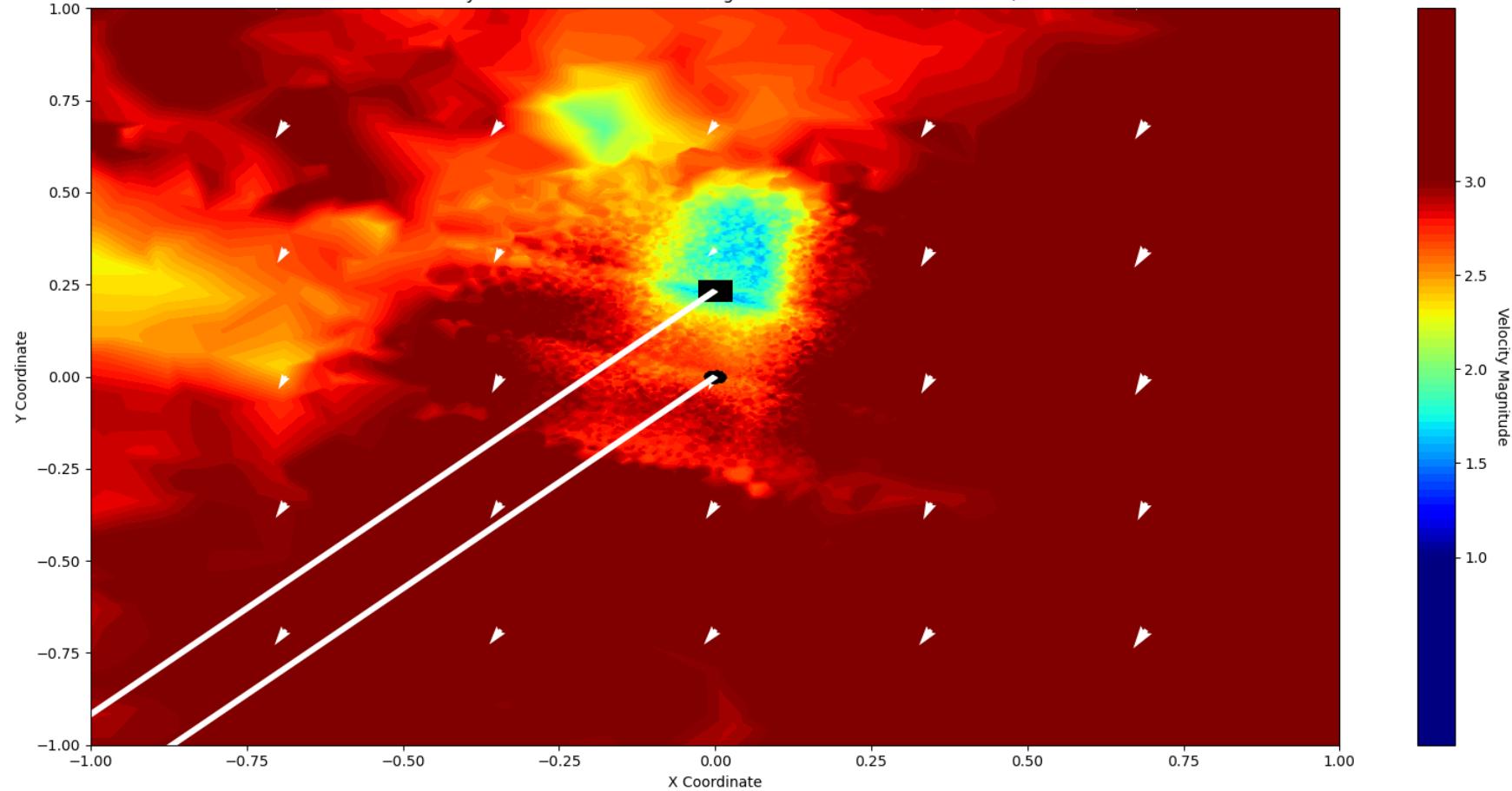
Total Velocity in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



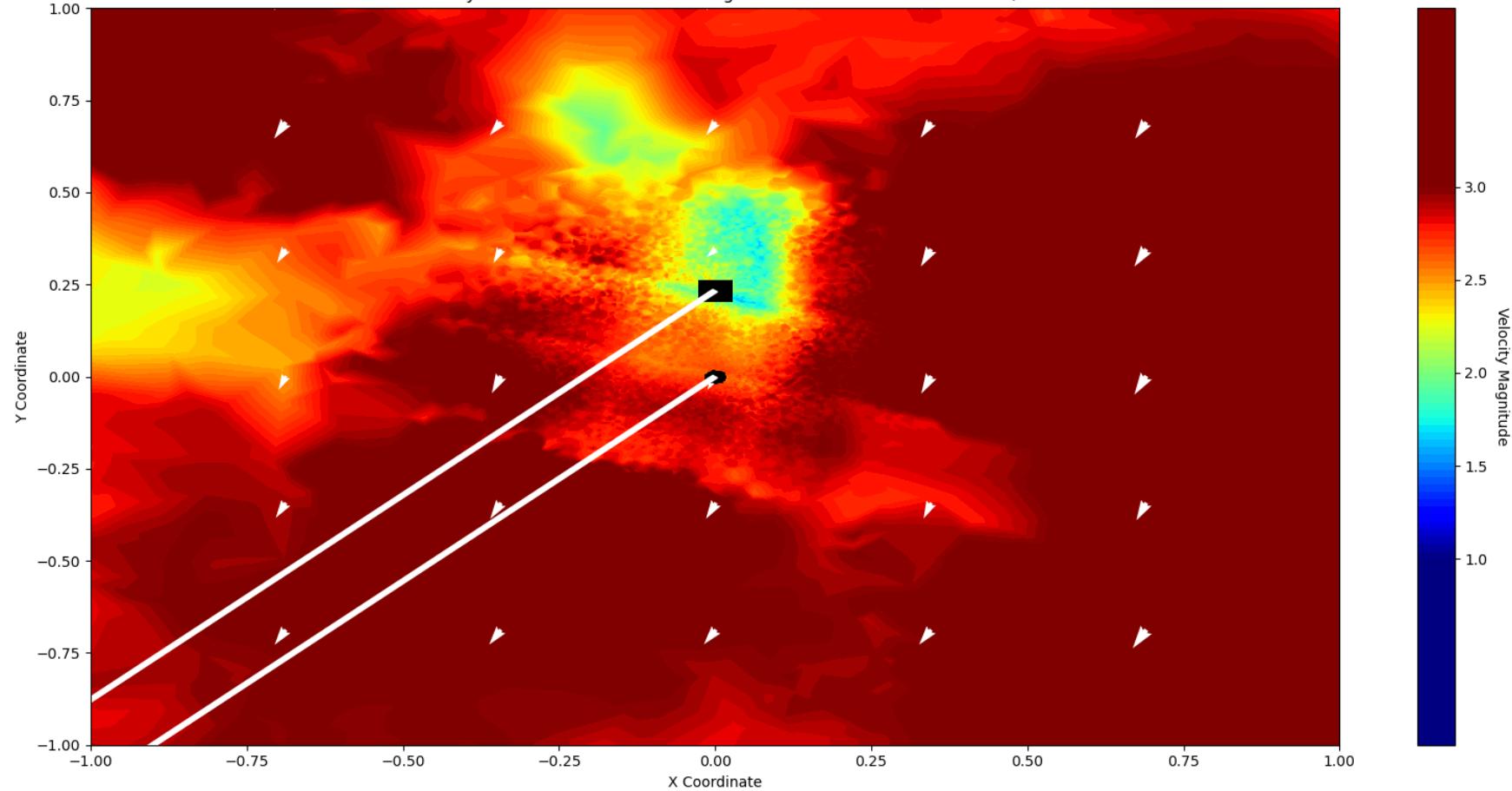
Total Velocity in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



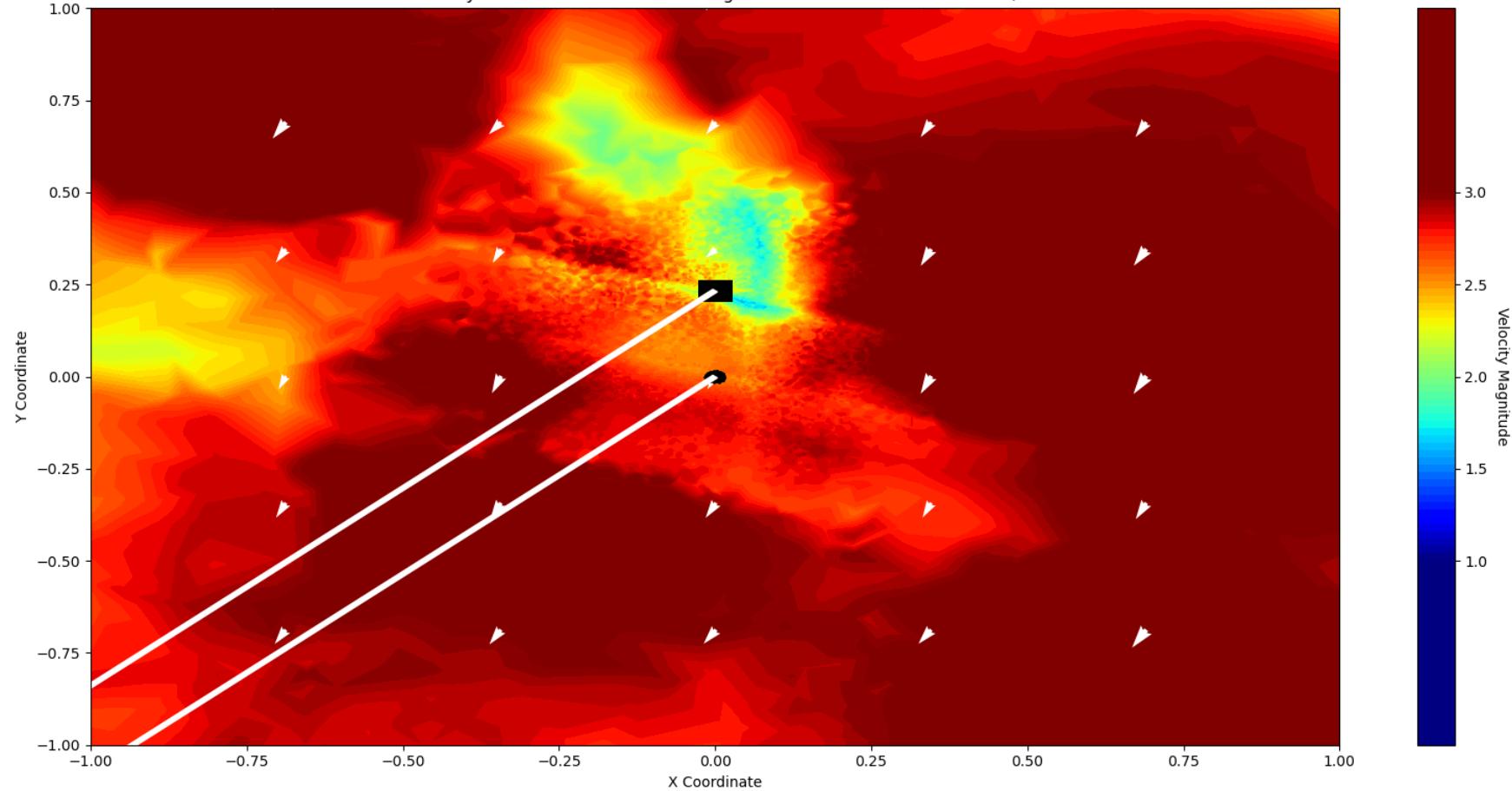
Total Velocity in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



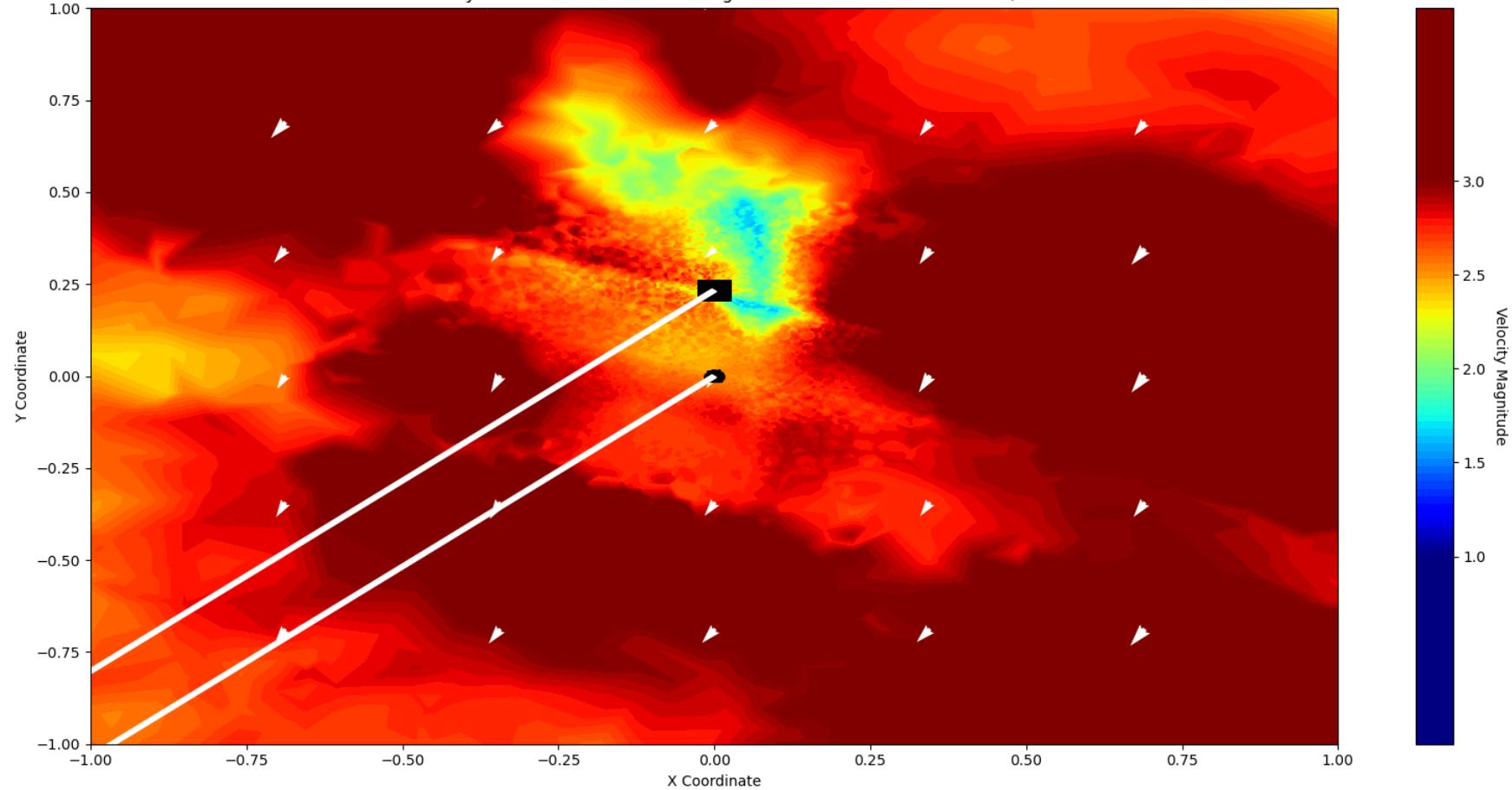
Total Velocity in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



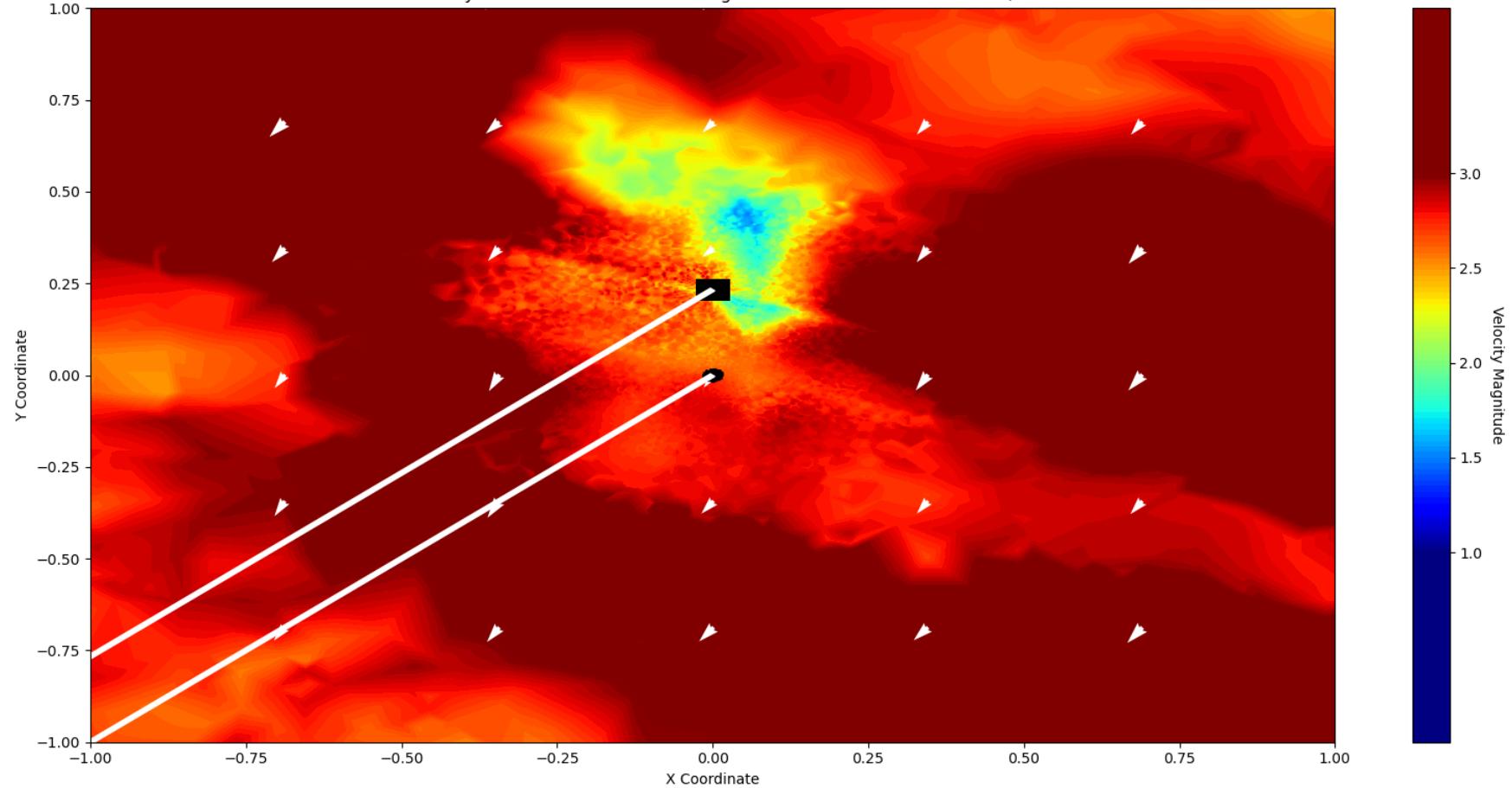
Total Velocity in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



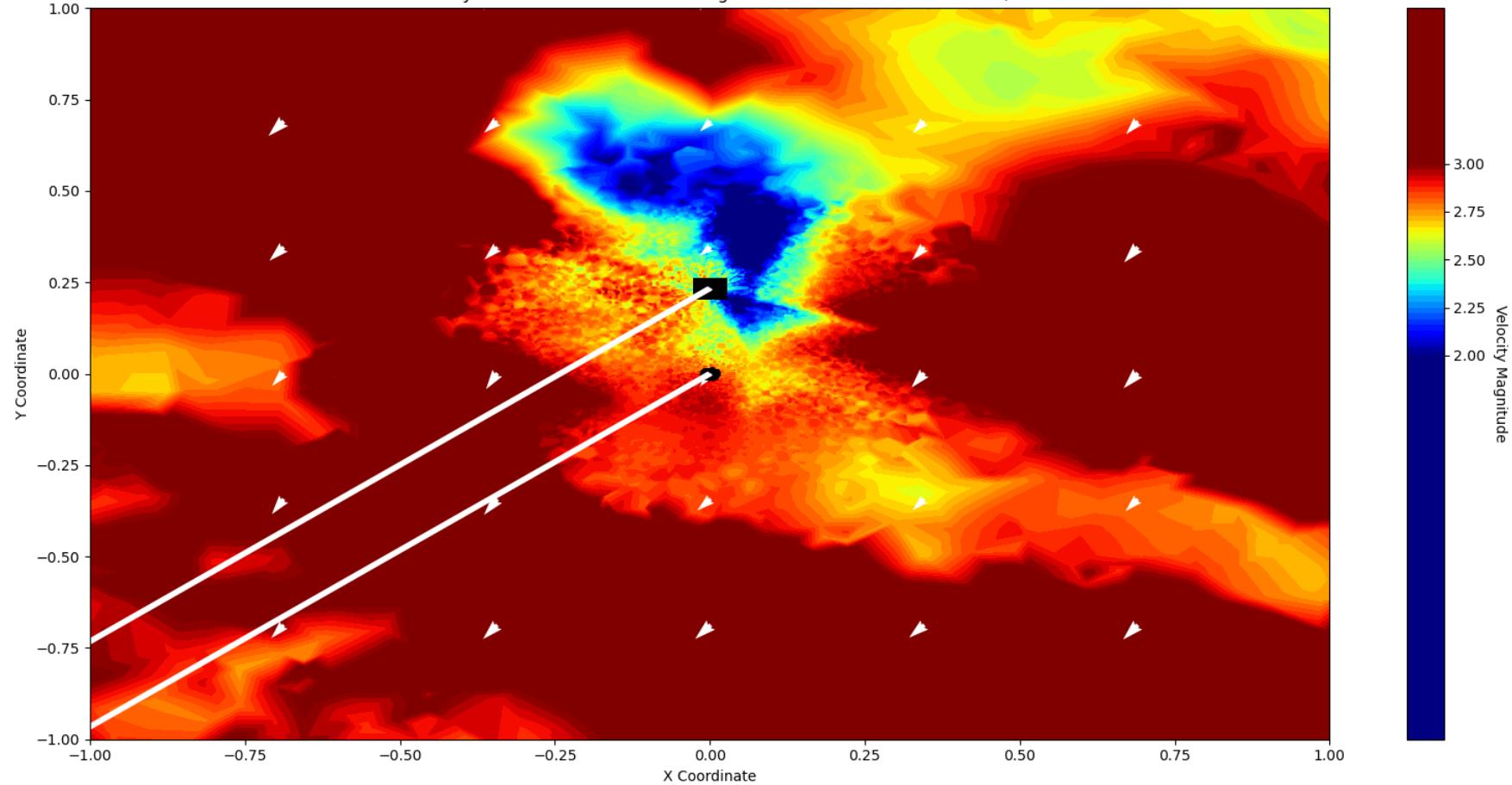
Total Velocity in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



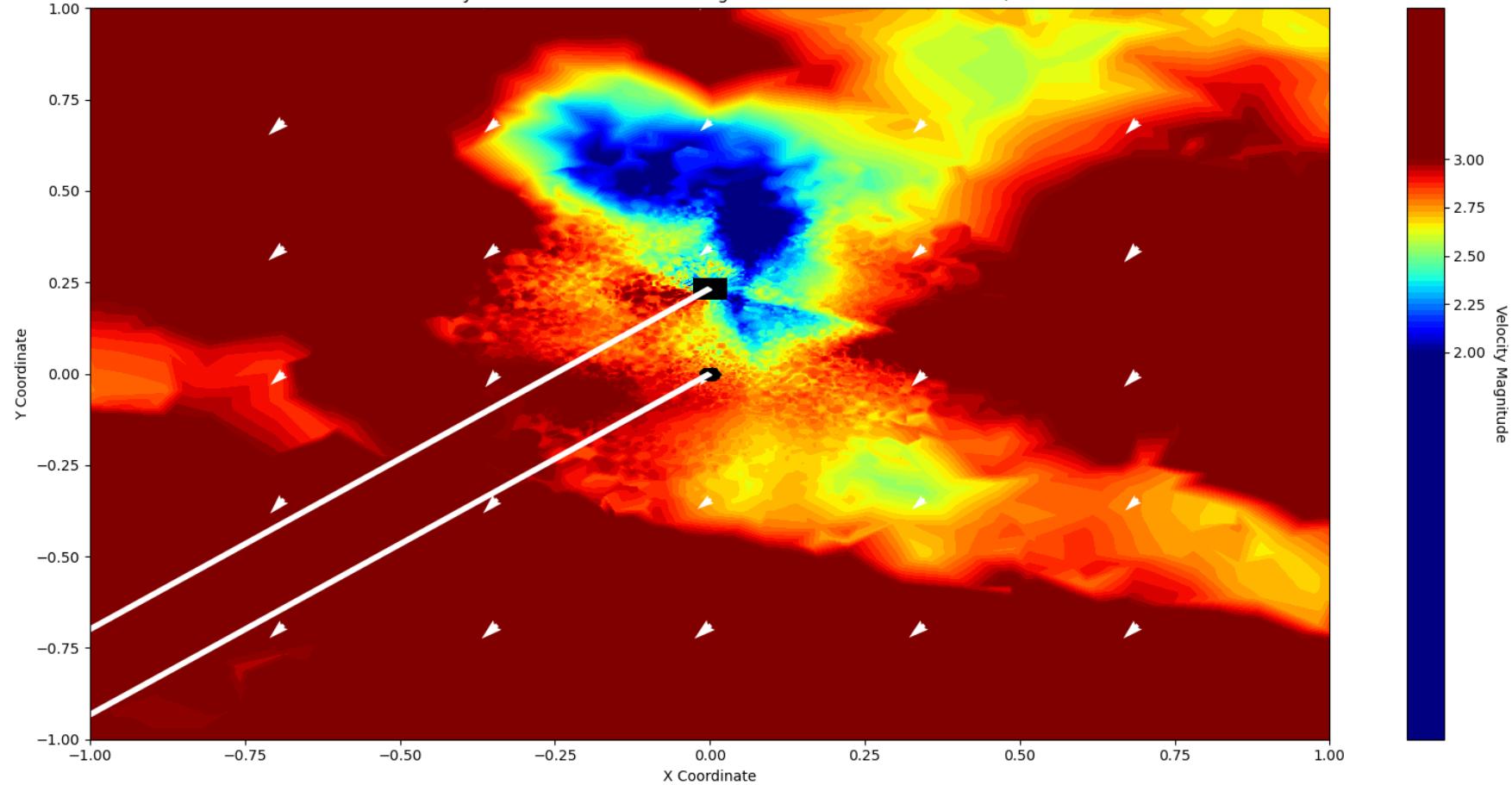
Total Velocity in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



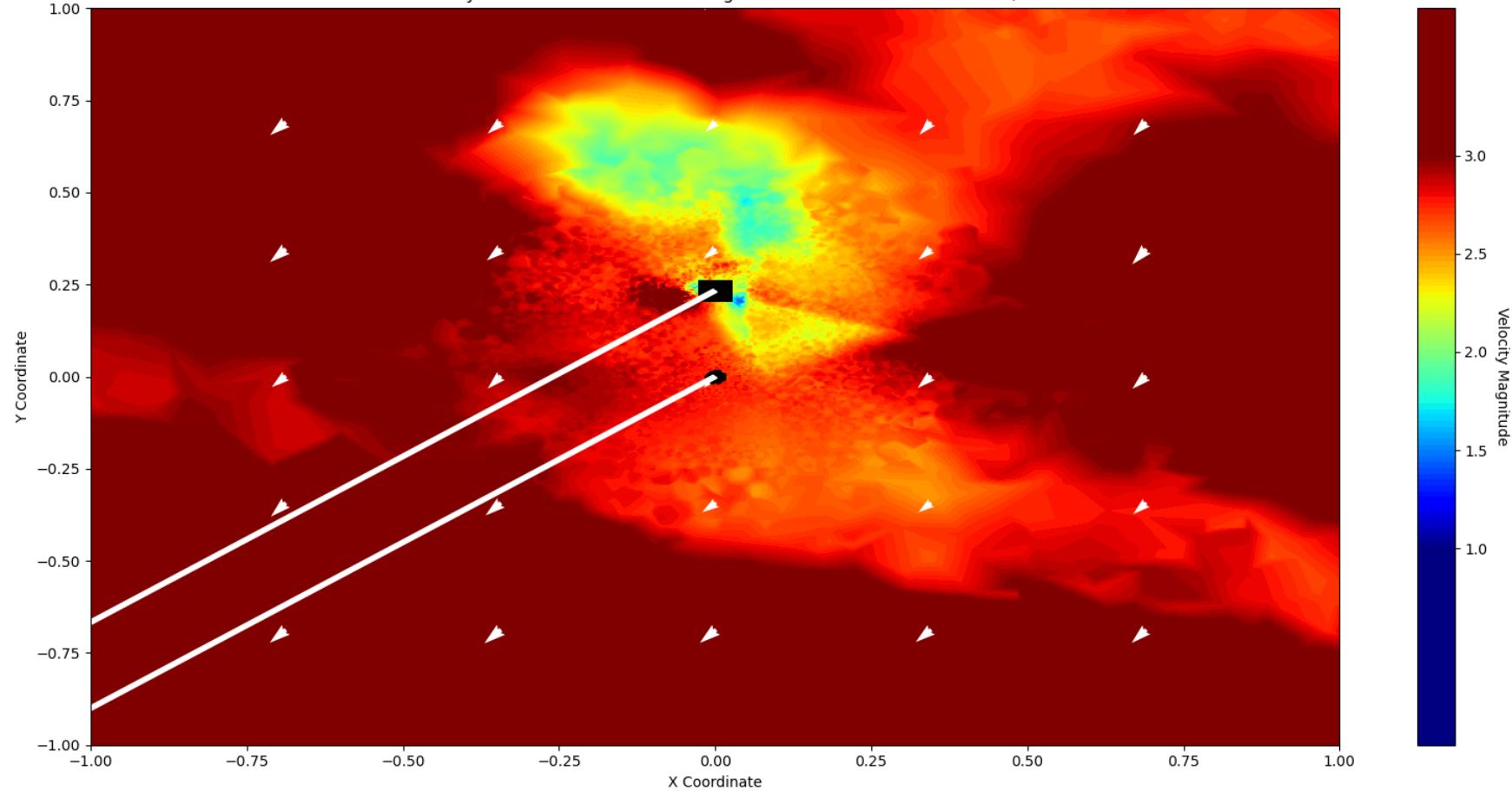
Total Velocity in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



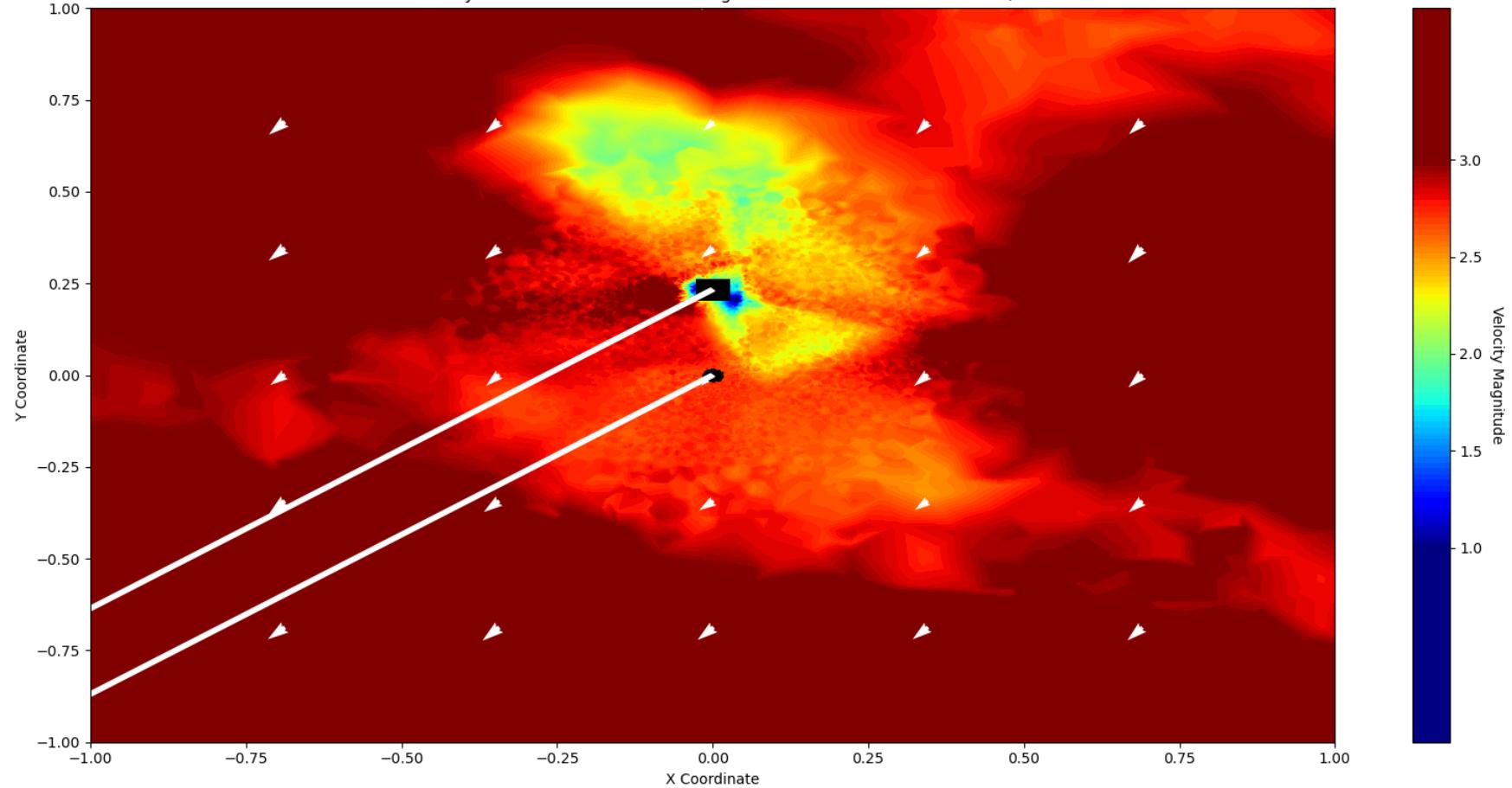
Total Velocity in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



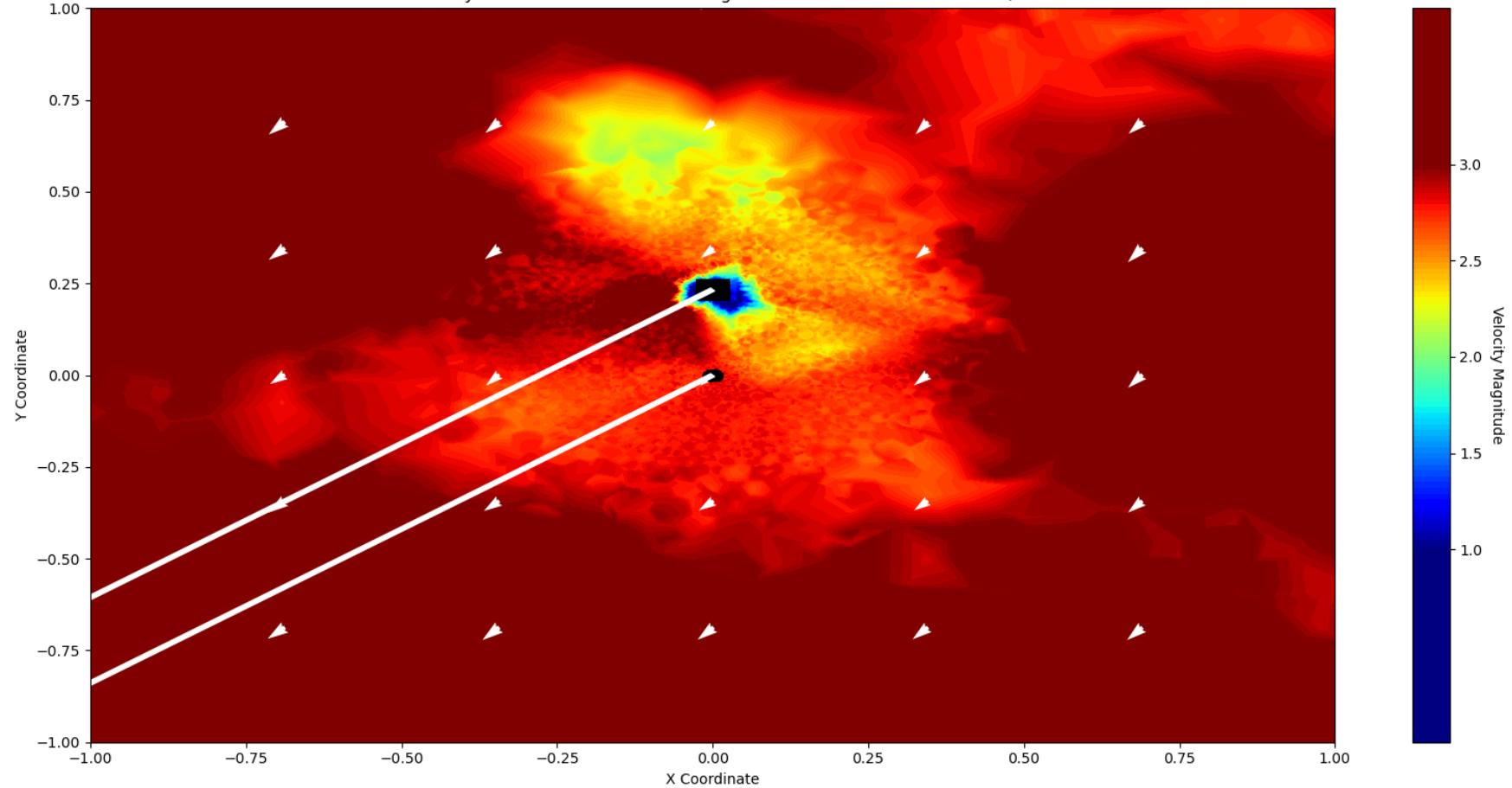
Total Velocity in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



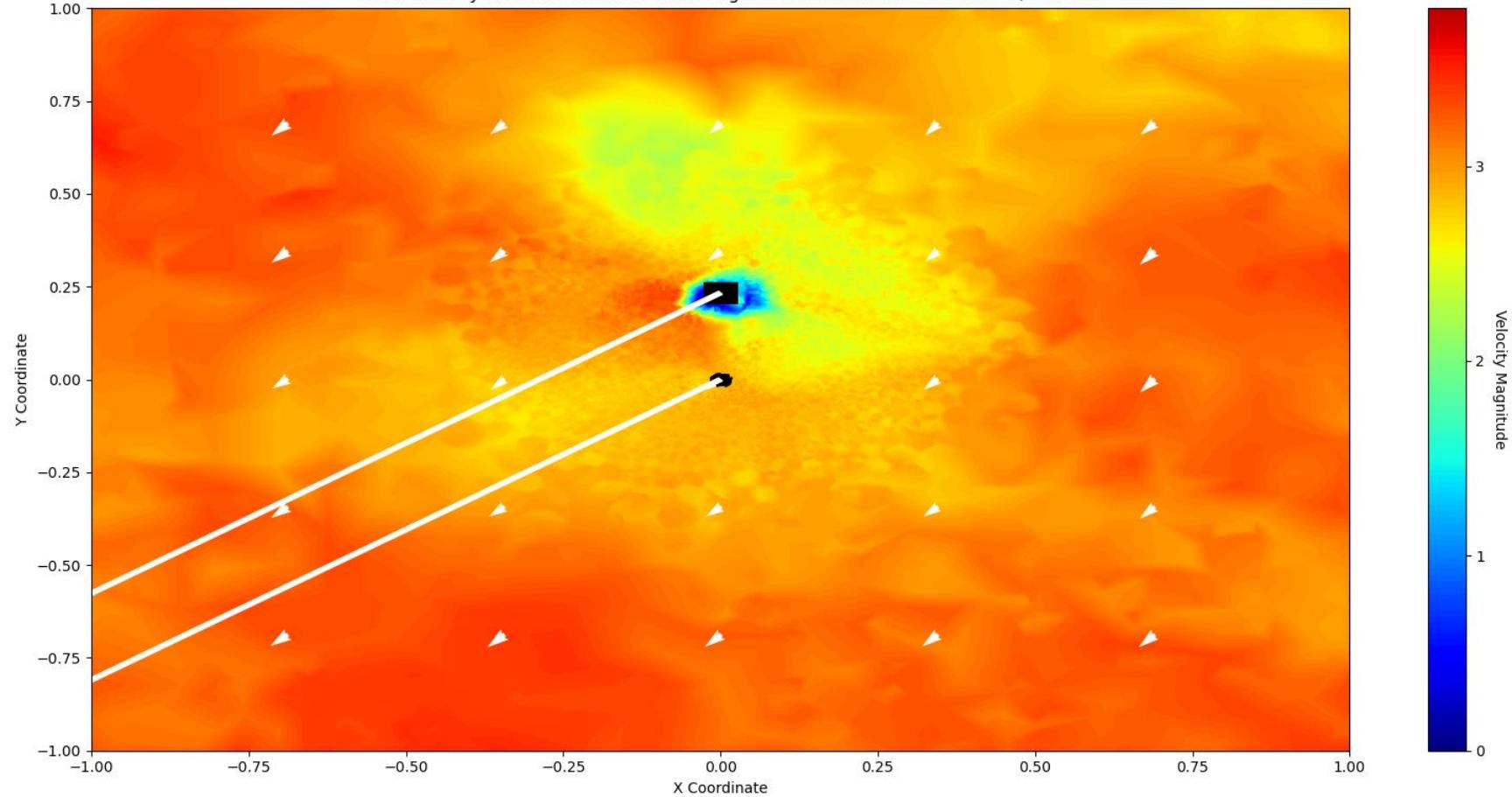
Total Velocity in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



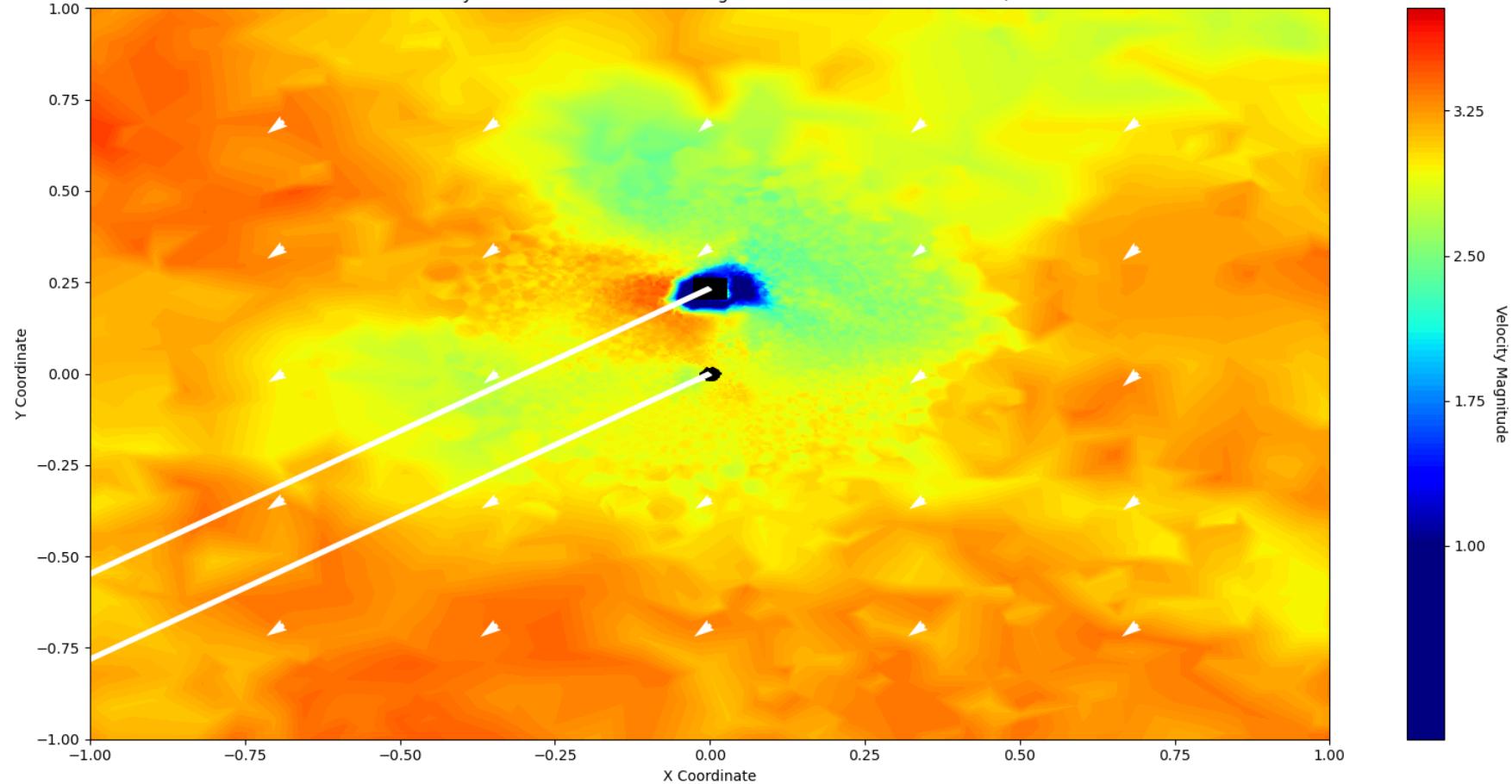
Total Velocity in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



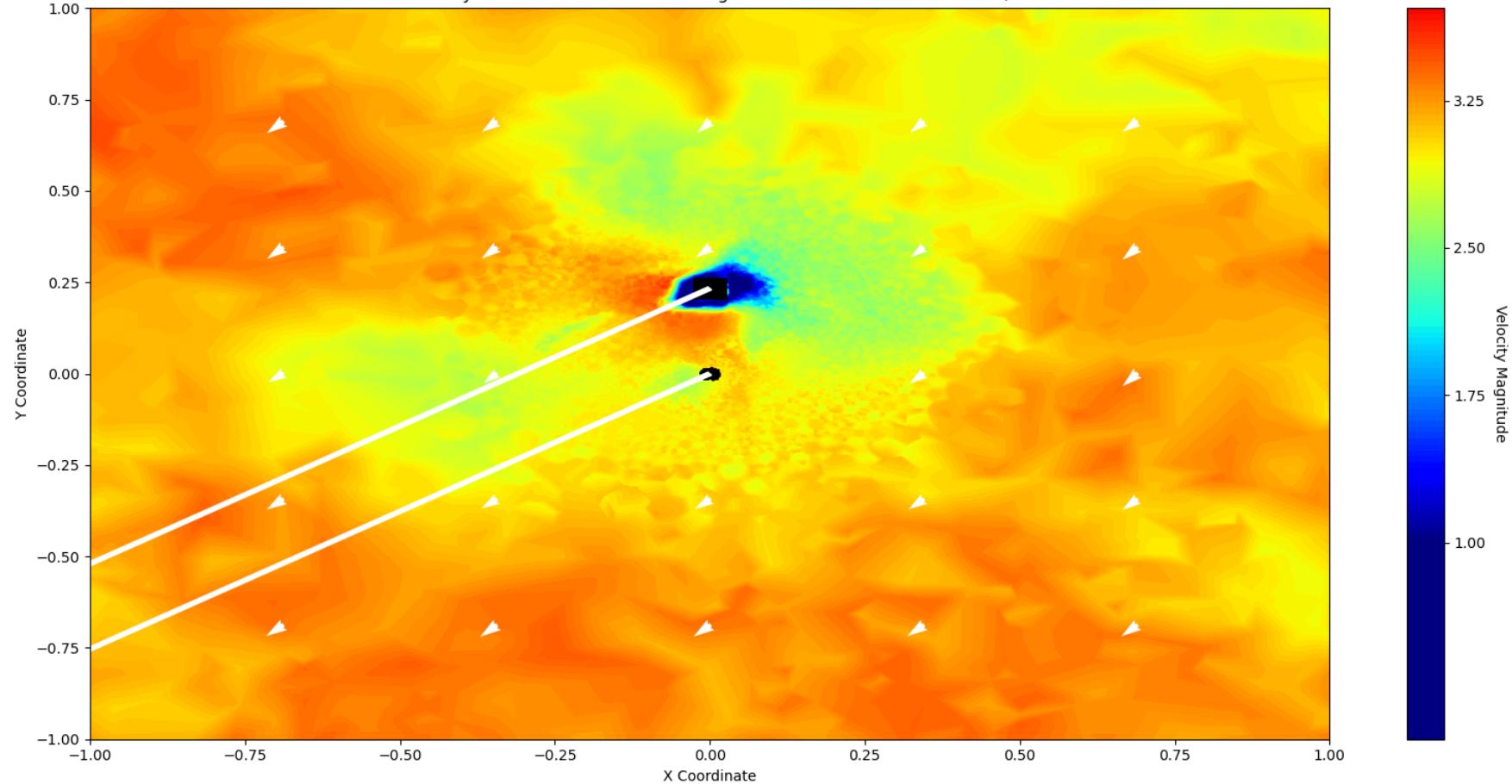
Total Velocity in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



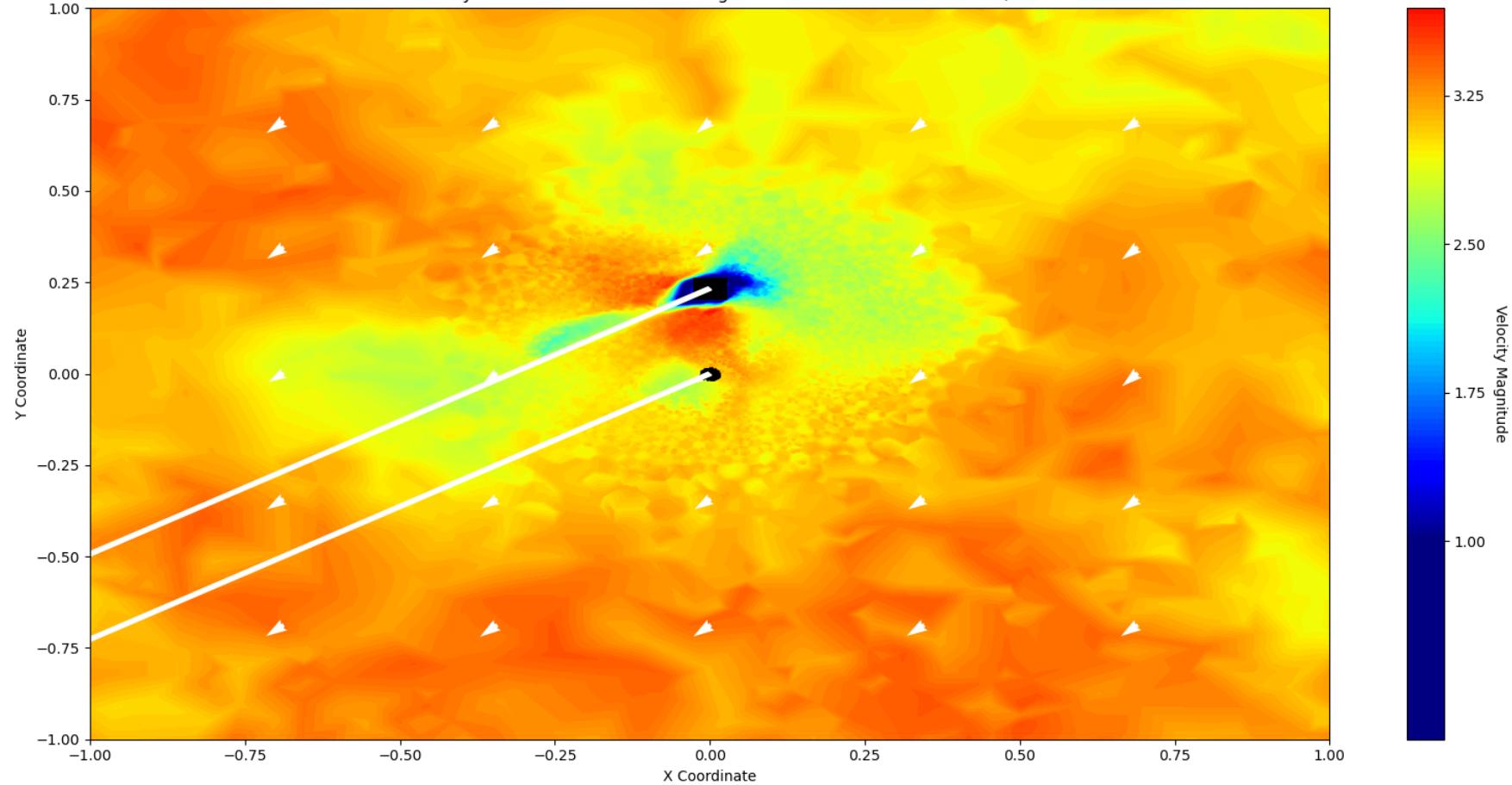
Total Velocity in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



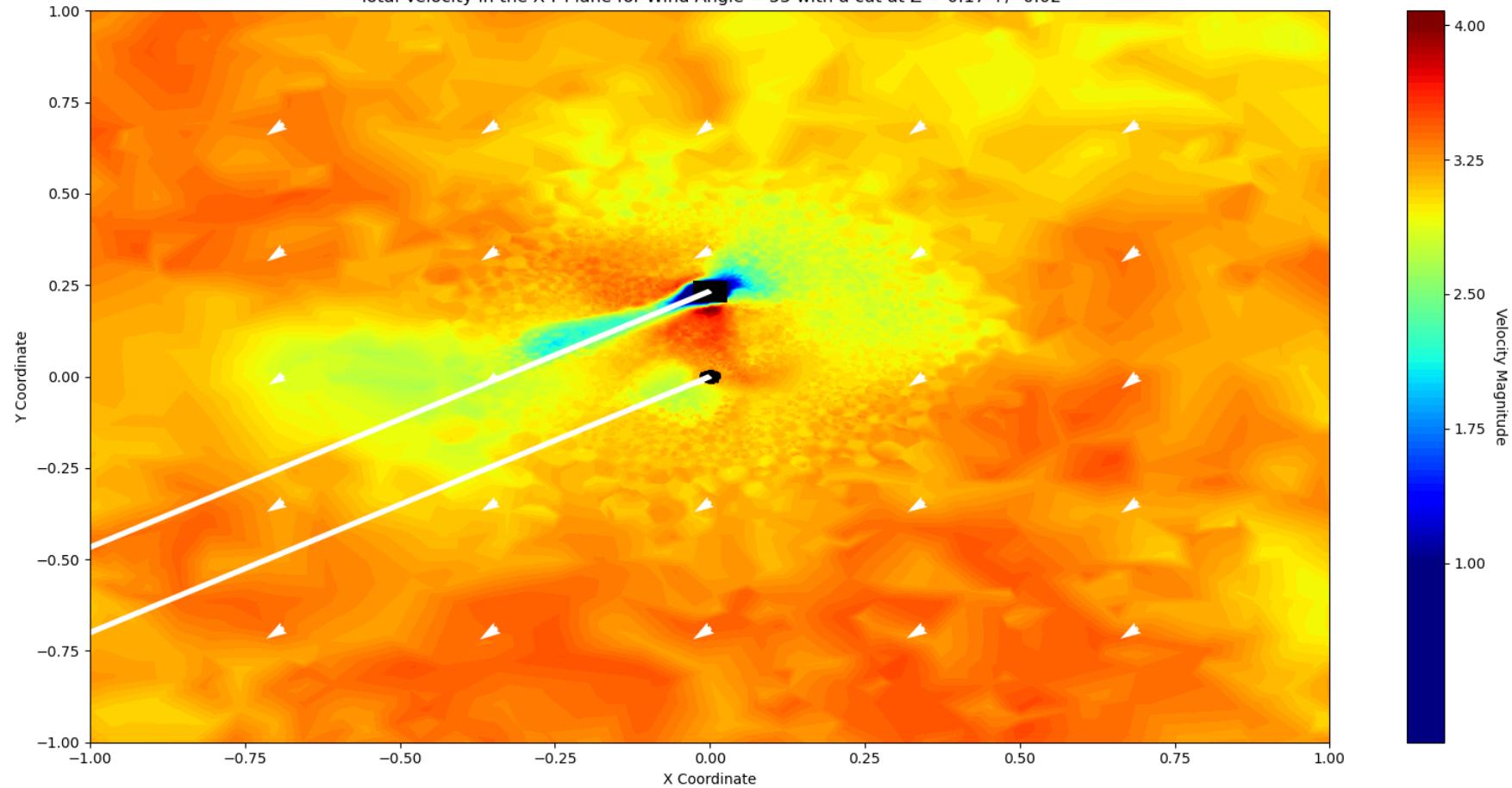
Total Velocity in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



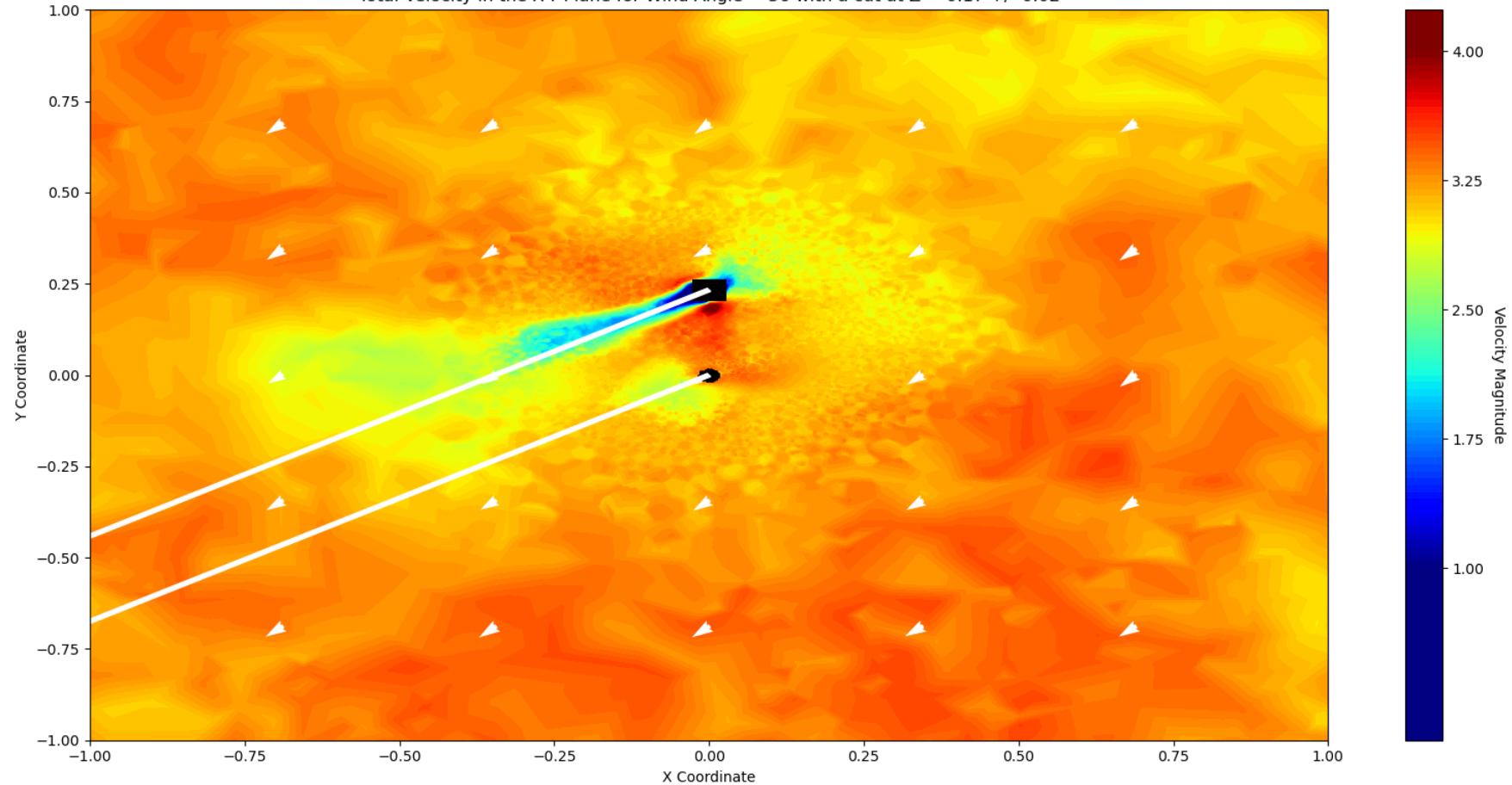
Total Velocity in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



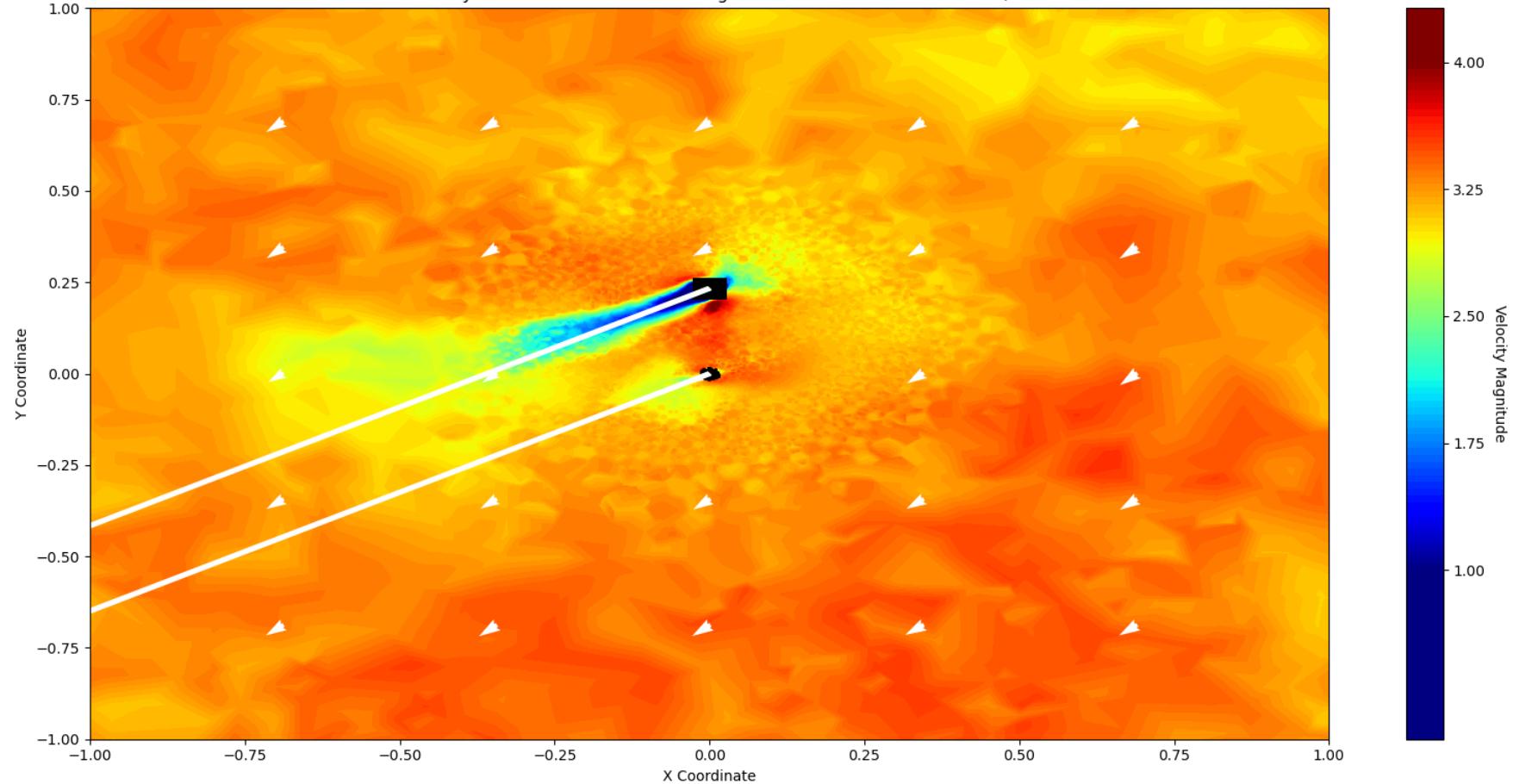
Total Velocity in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



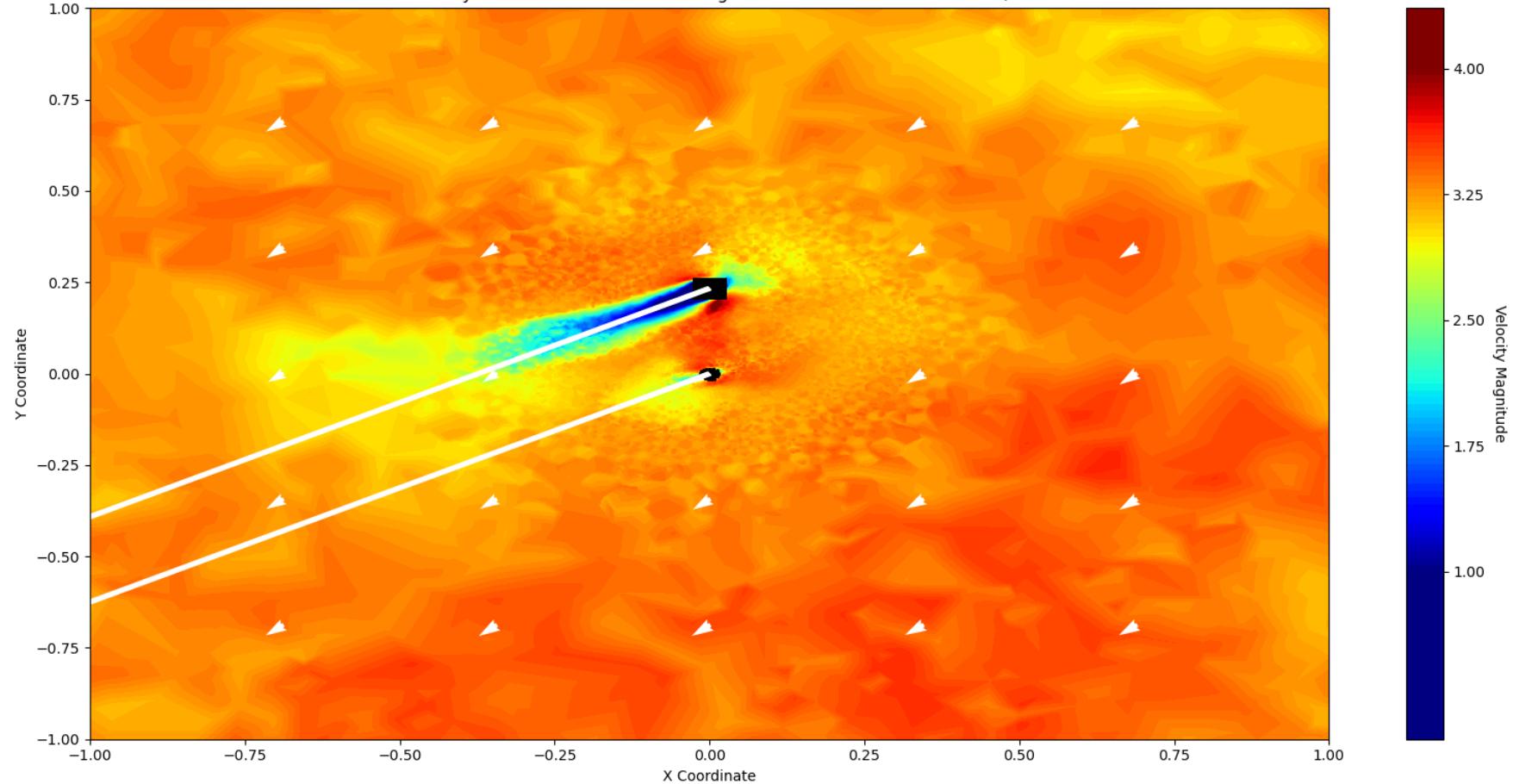
Total Velocity in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



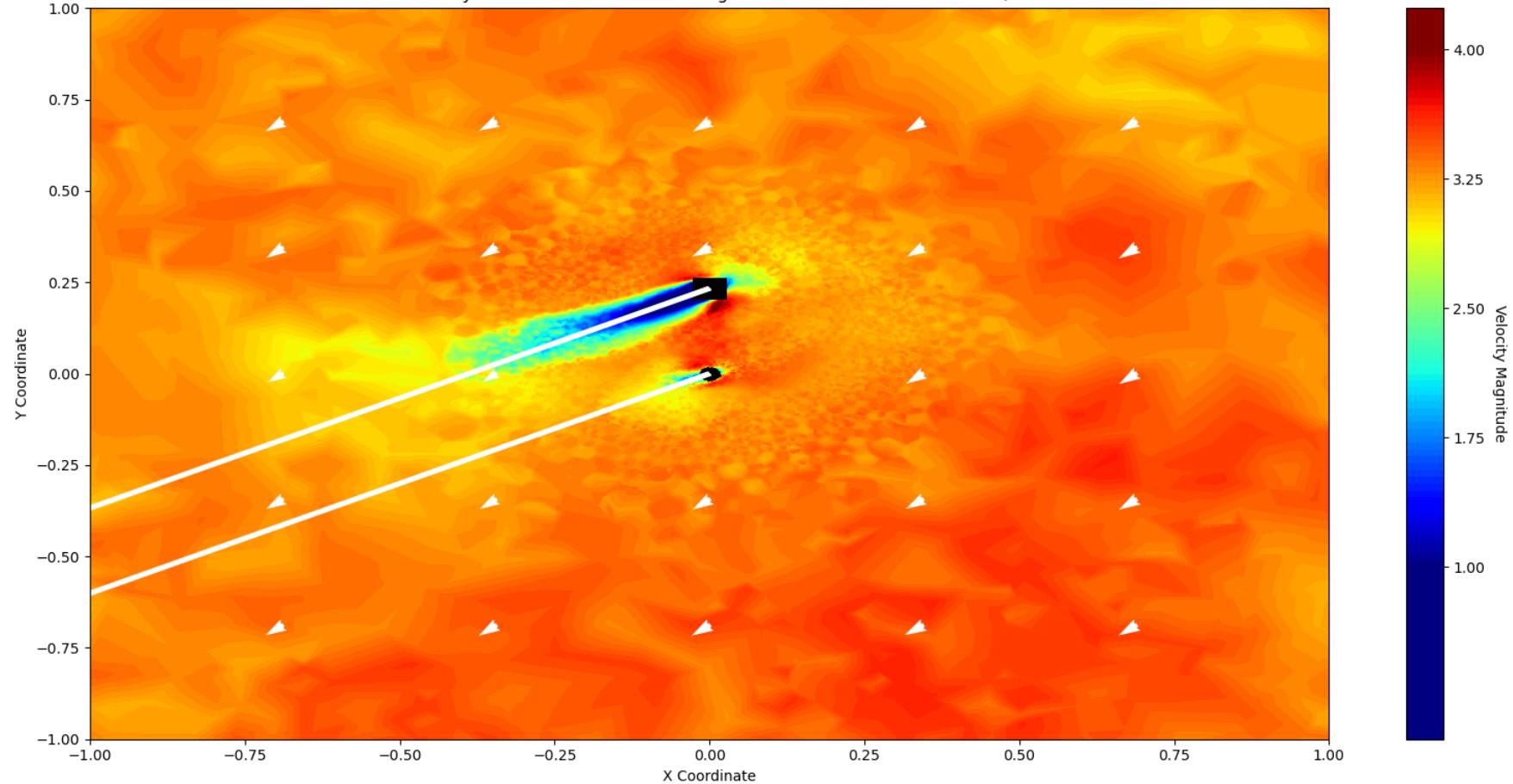
Total Velocity in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



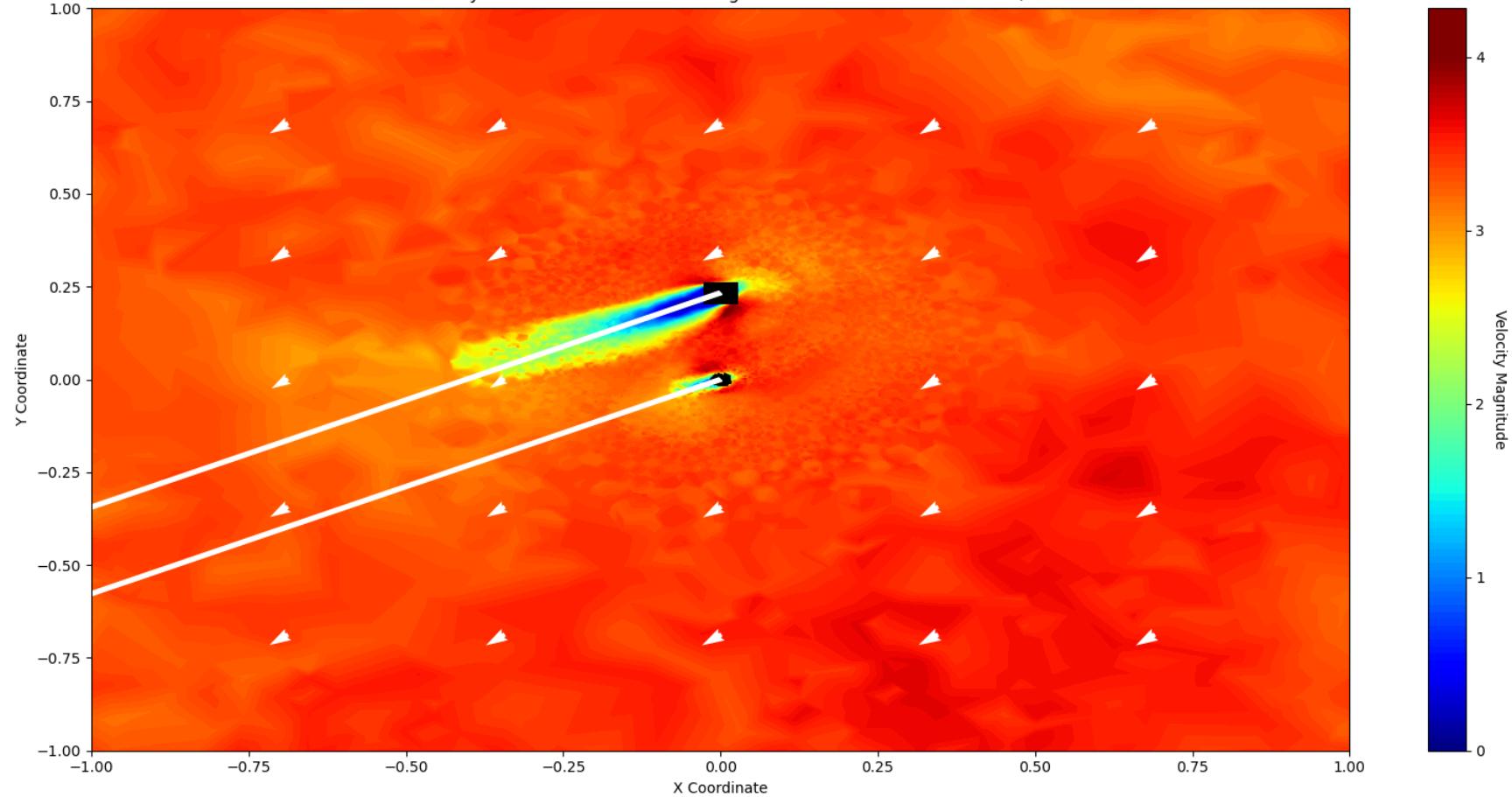
Total Velocity in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



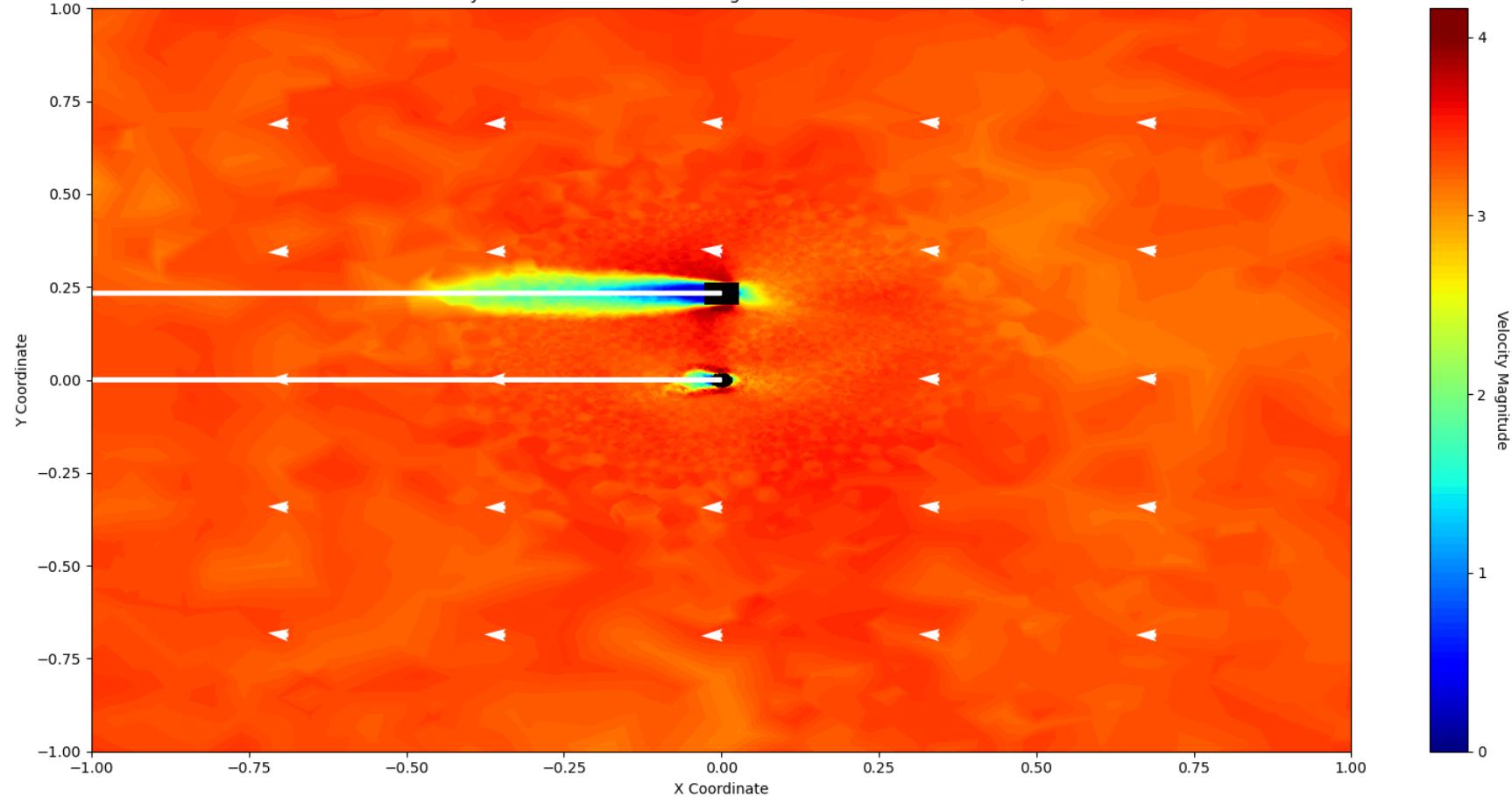
Total Velocity in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



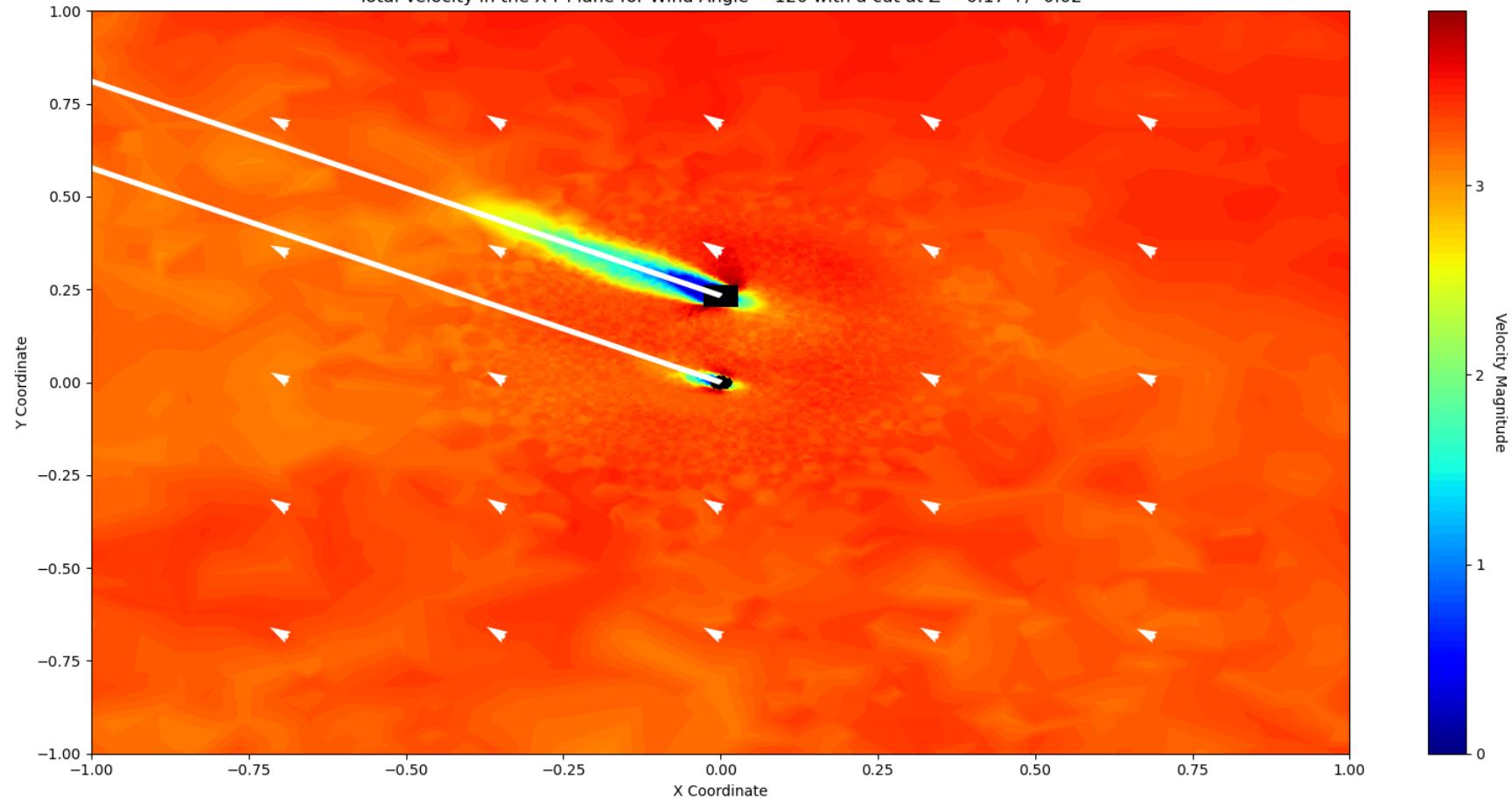
Total Velocity in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



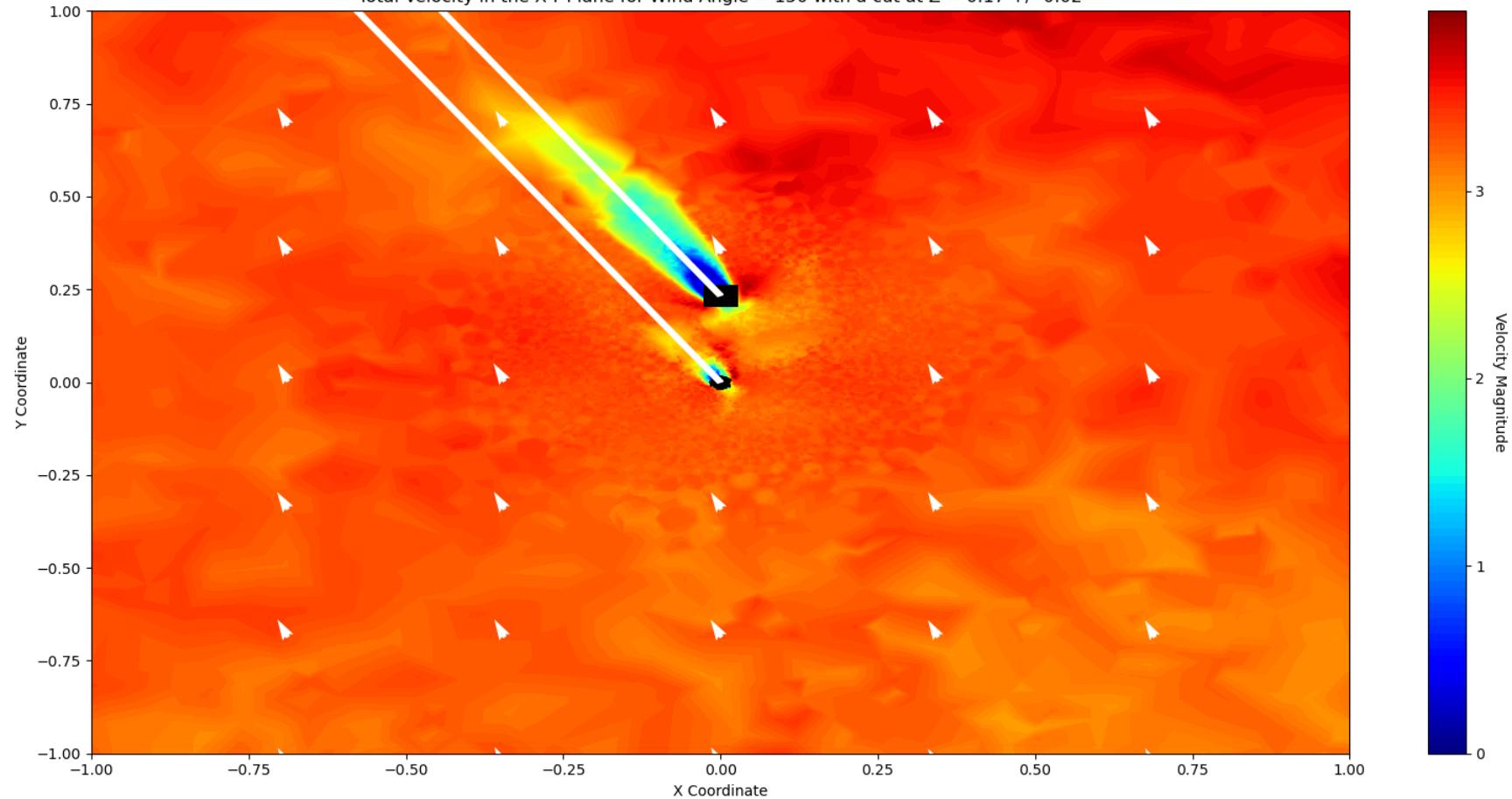
Total Velocity in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



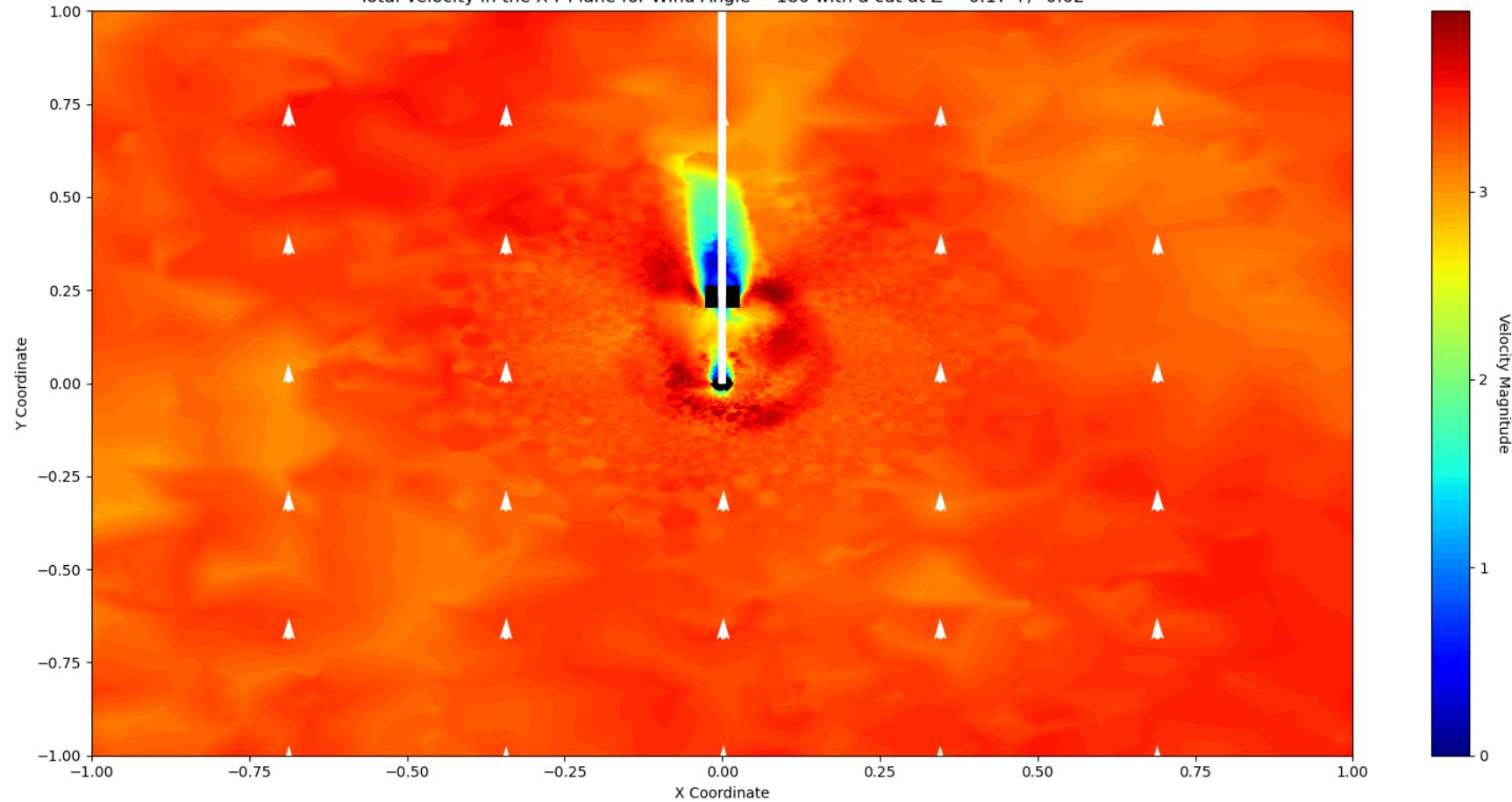
Total Velocity in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



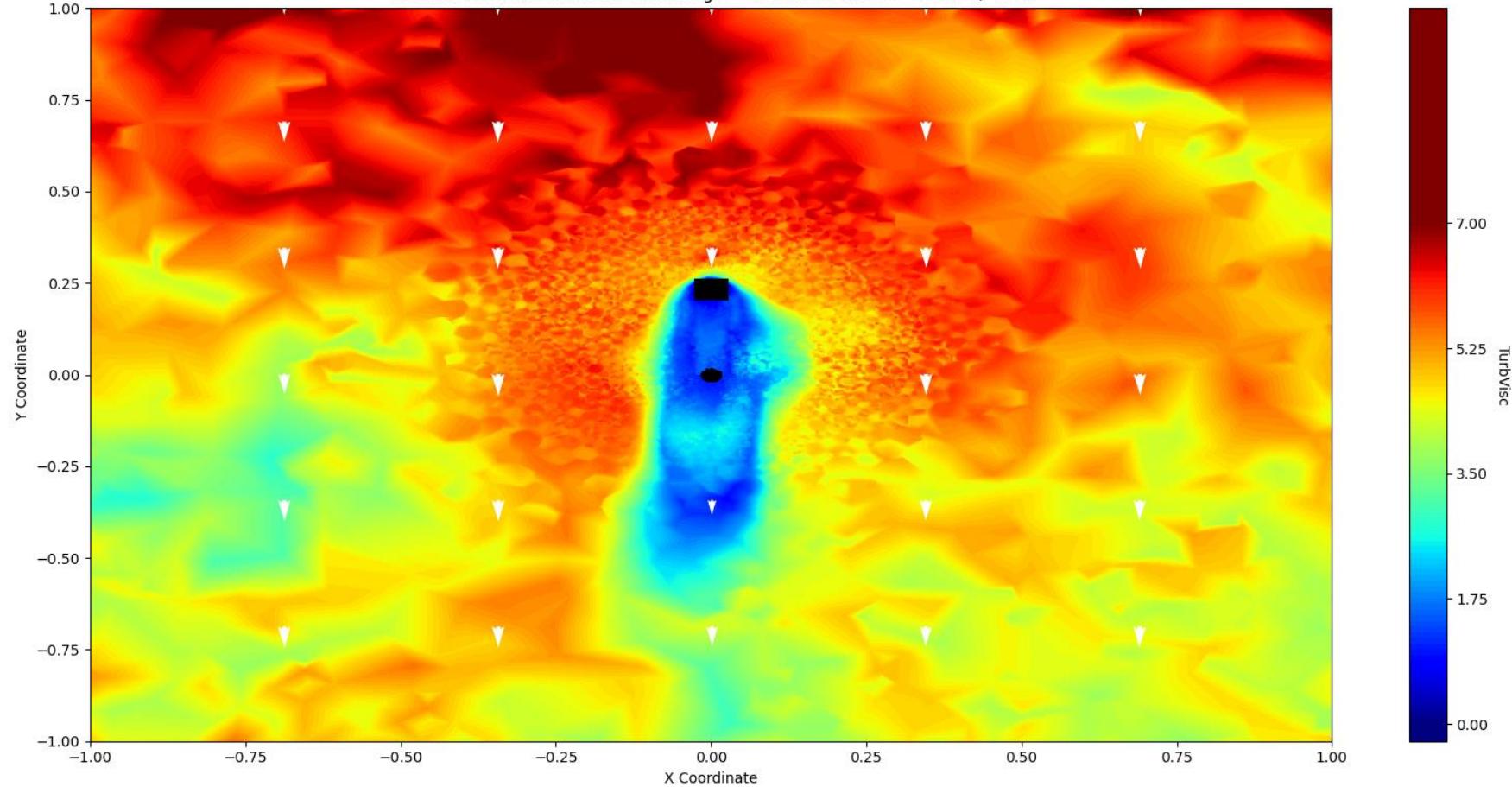
Total Velocity in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



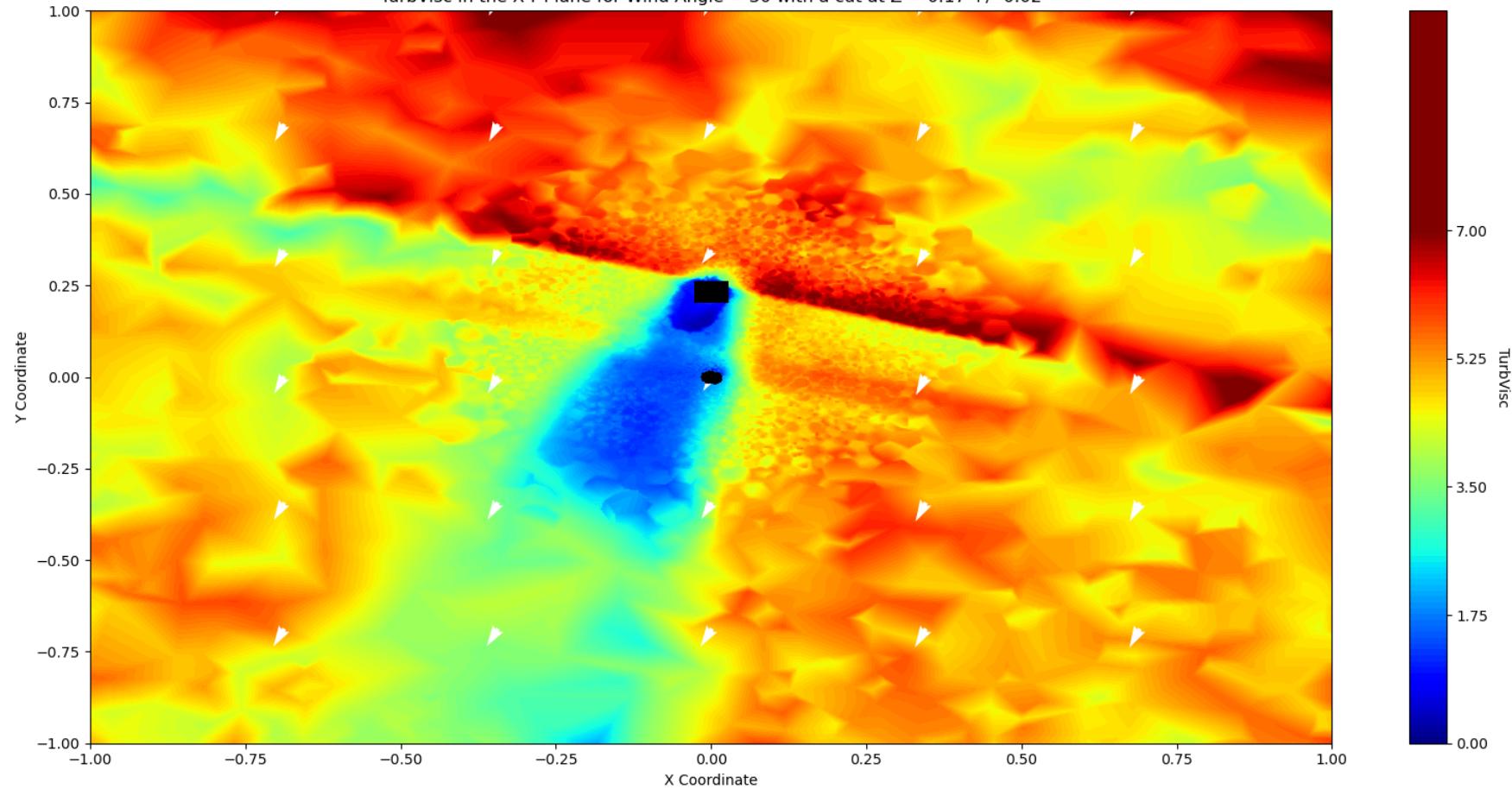
Total Velocity in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



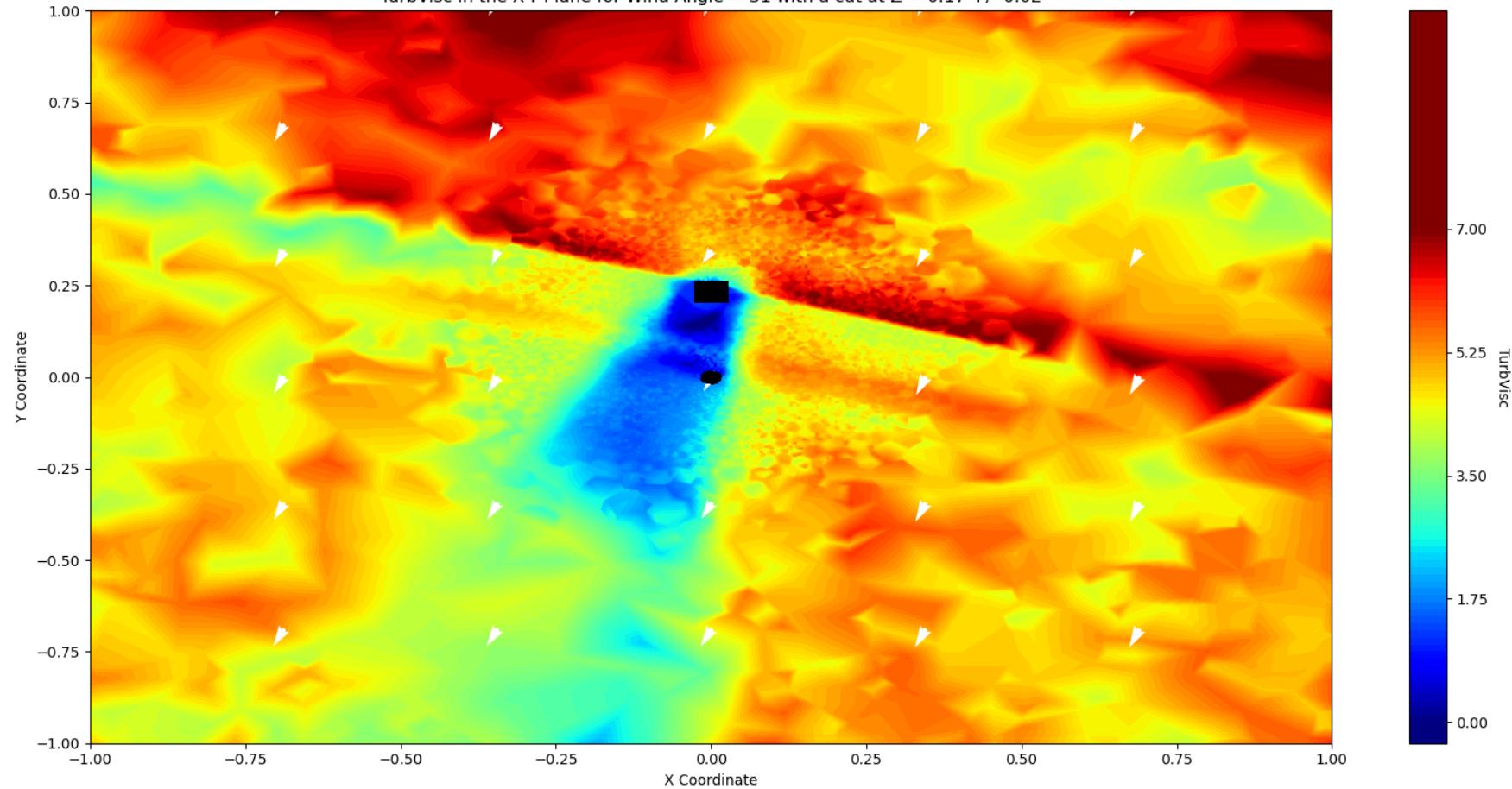
TurbVisc in the X-Y Plane for Wind Angle = 0 with a cut at Z = 0.17 +/- 0.02



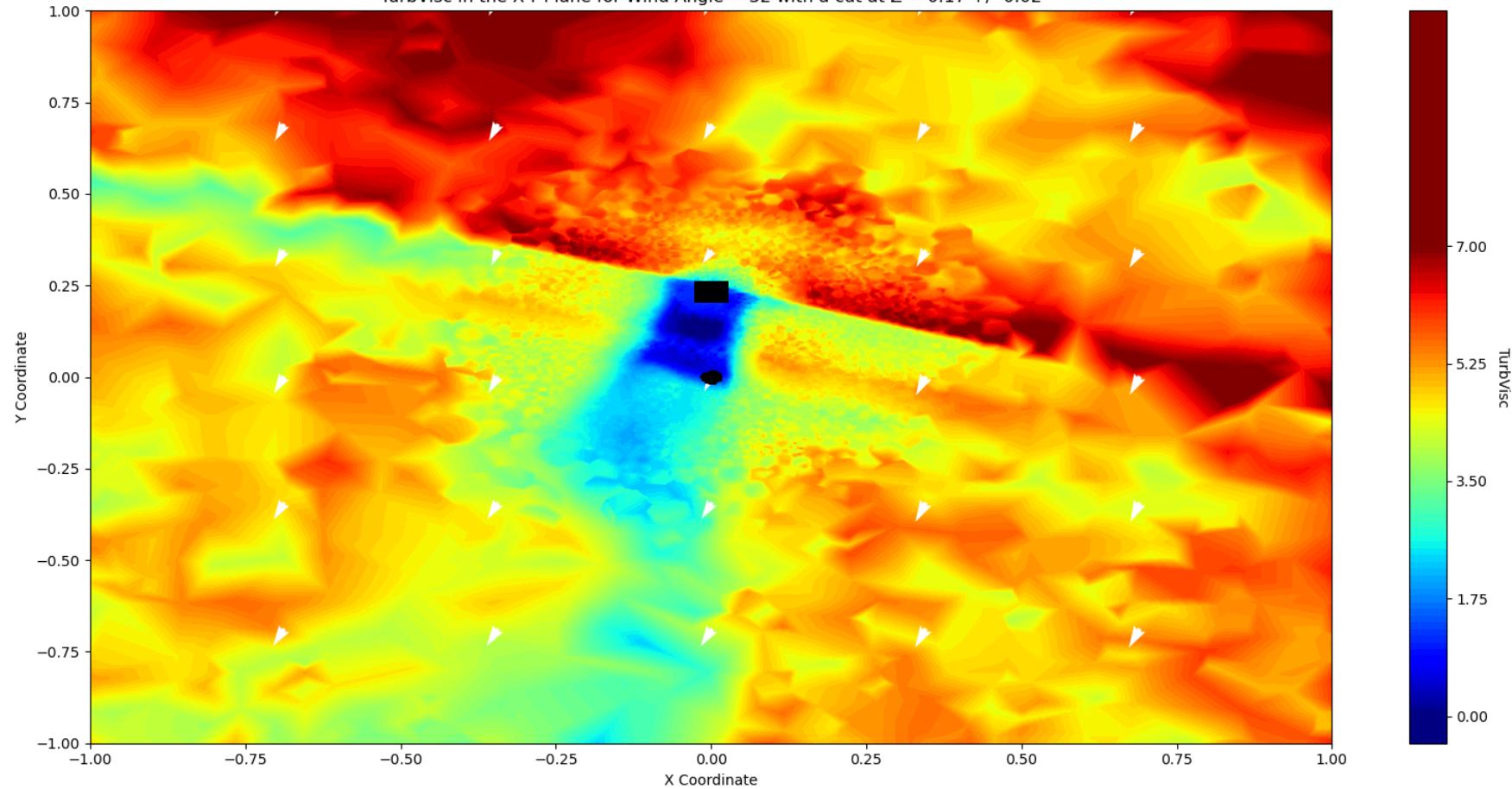
TurbVisc in the X-Y Plane for Wind Angle = 30 with a cut at Z = 0.17 +/- 0.02



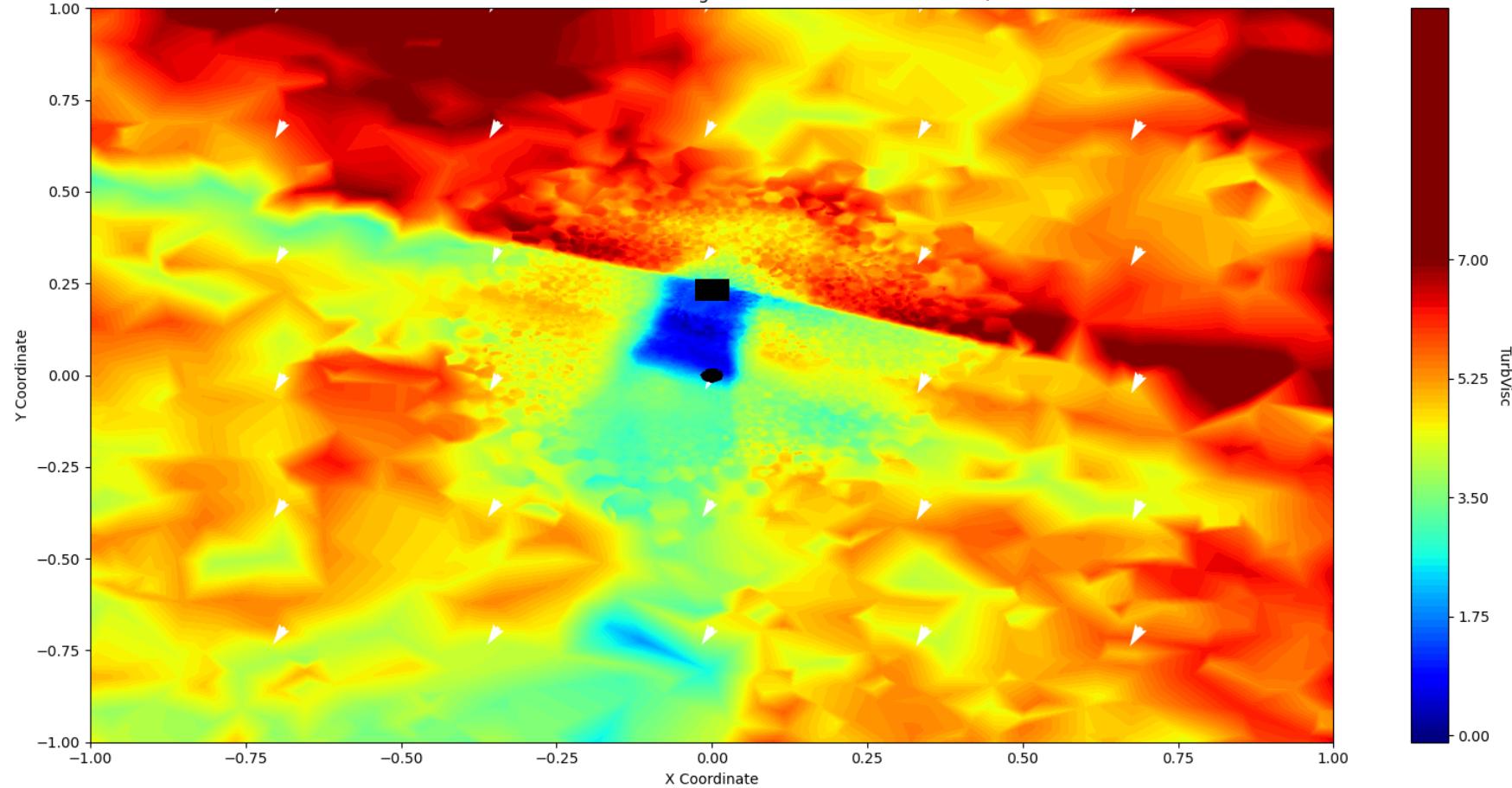
TurbVisc in the X-Y Plane for Wind Angle = 31 with a cut at Z = 0.17 +/- 0.02



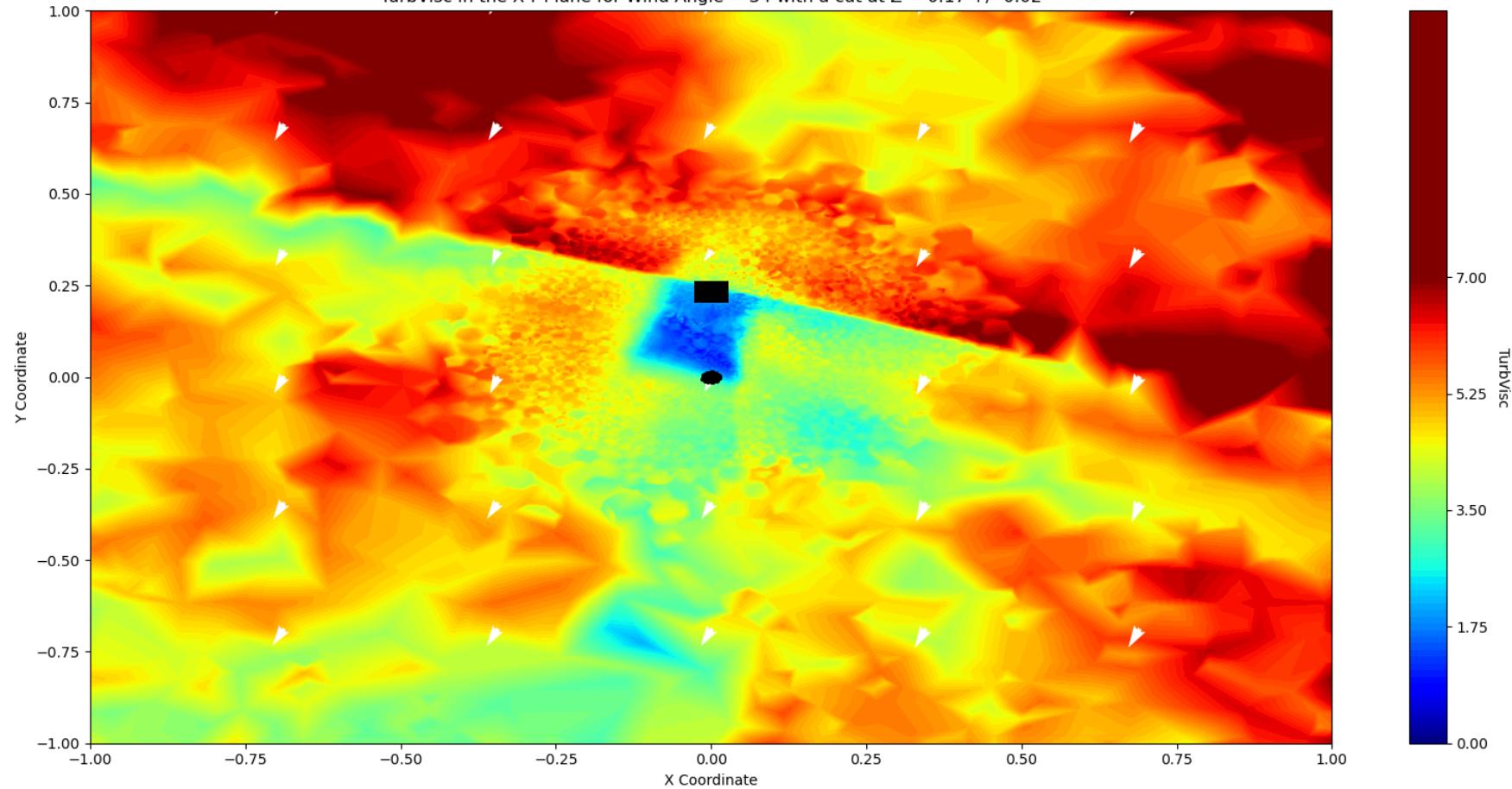
TurbVisc in the X-Y Plane for Wind Angle = 32 with a cut at Z = 0.17 +/- 0.02



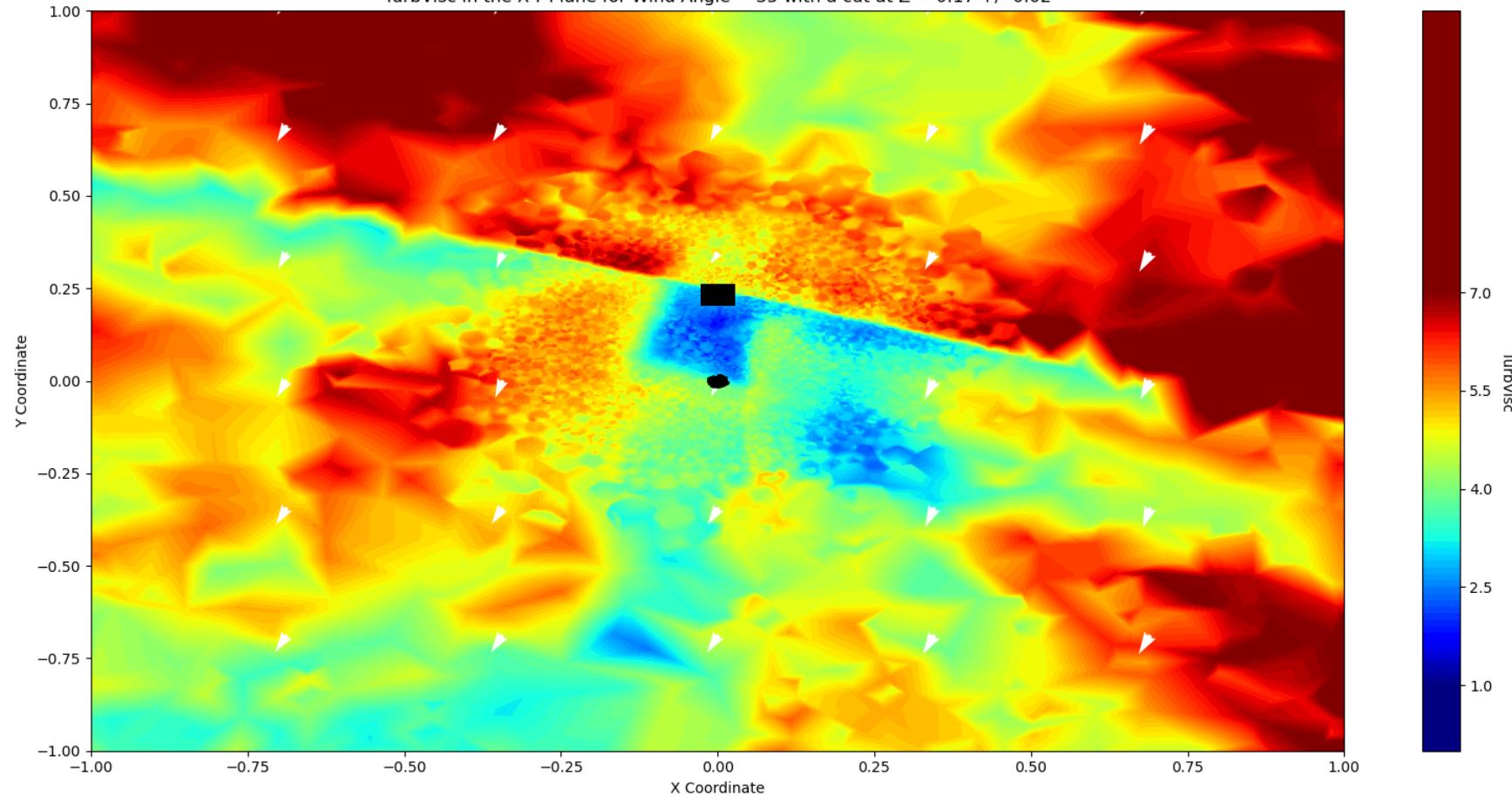
TurbVisc in the X-Y Plane for Wind Angle = 33 with a cut at Z = 0.17 +/- 0.02



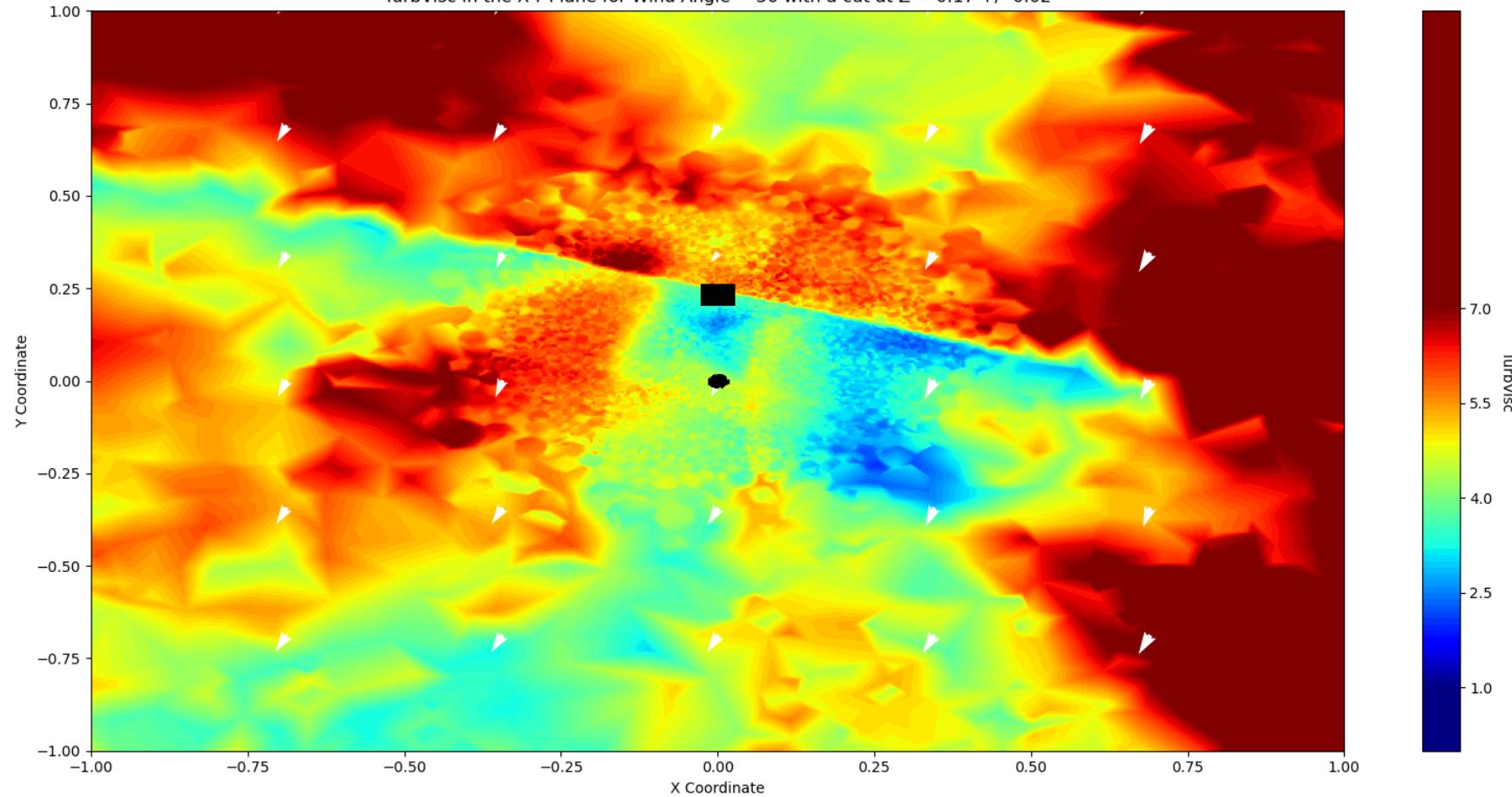
TurbVisc in the X-Y Plane for Wind Angle = 34 with a cut at Z = 0.17 +/- 0.02



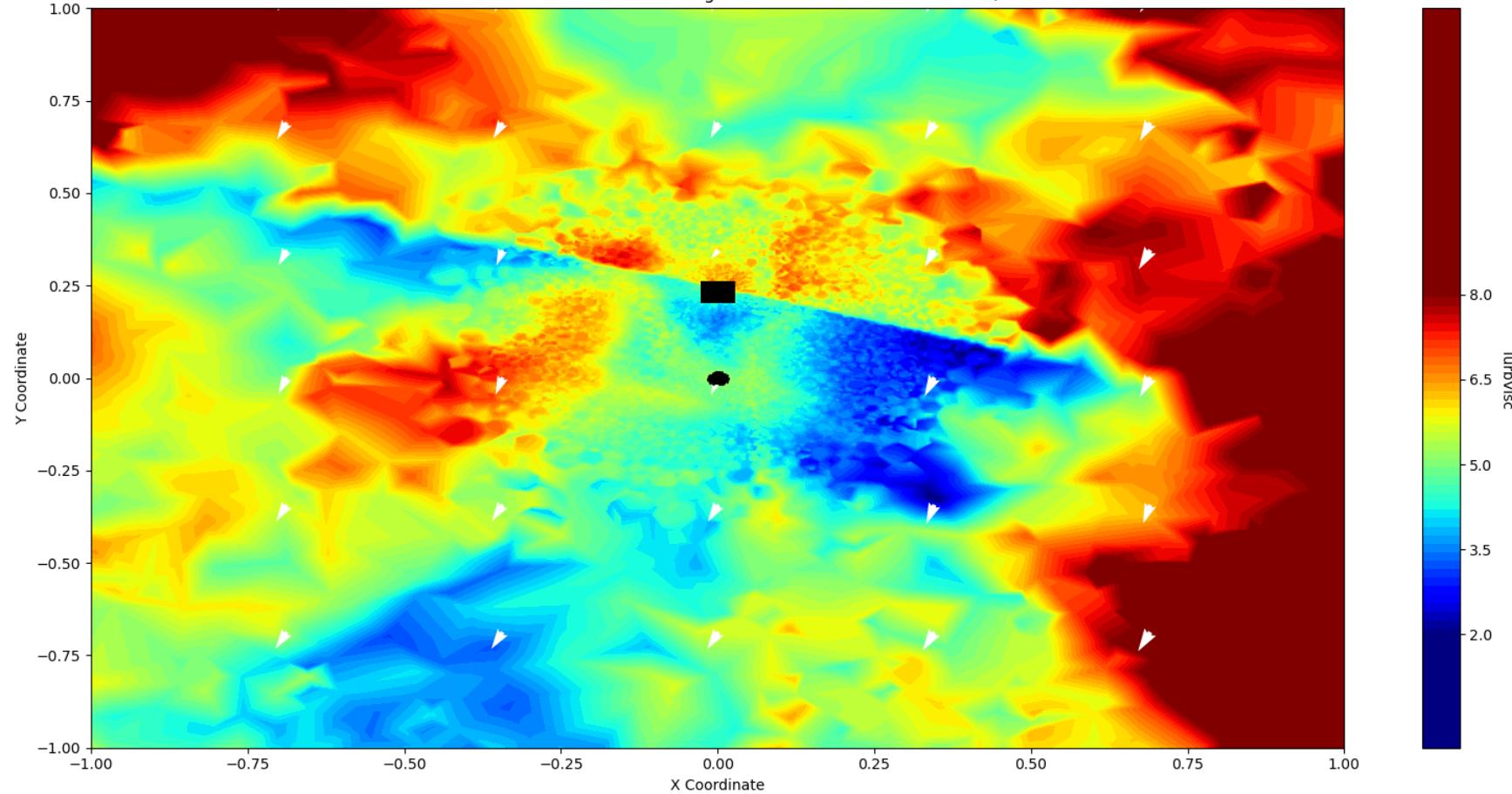
TurbVisc in the X-Y Plane for Wind Angle = 35 with a cut at Z = 0.17 +/- 0.02



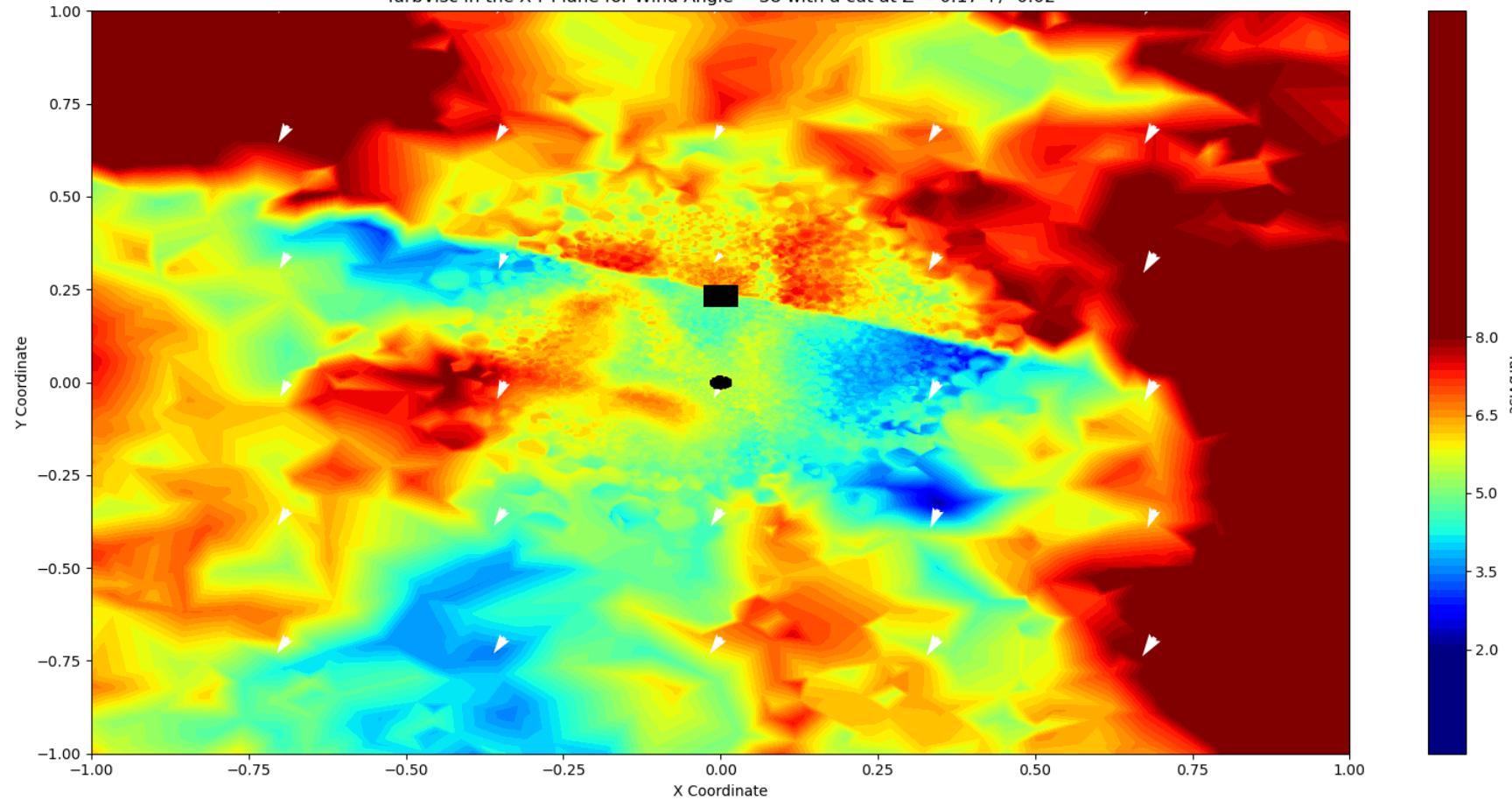
TurbVisc in the X-Y Plane for Wind Angle = 36 with a cut at Z = 0.17 +/- 0.02



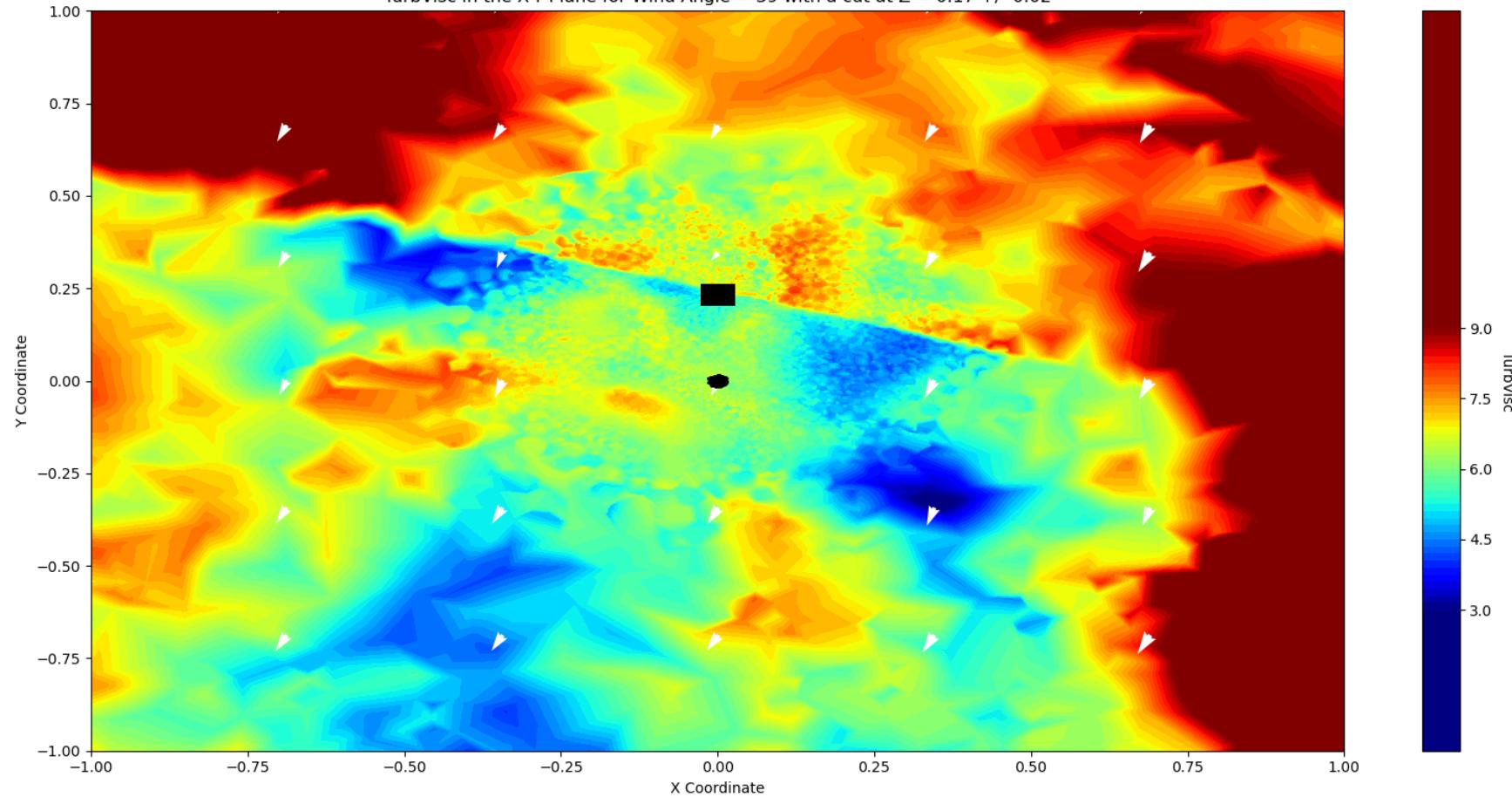
TurbVisc in the X-Y Plane for Wind Angle = 37 with a cut at Z = 0.17 +/- 0.02



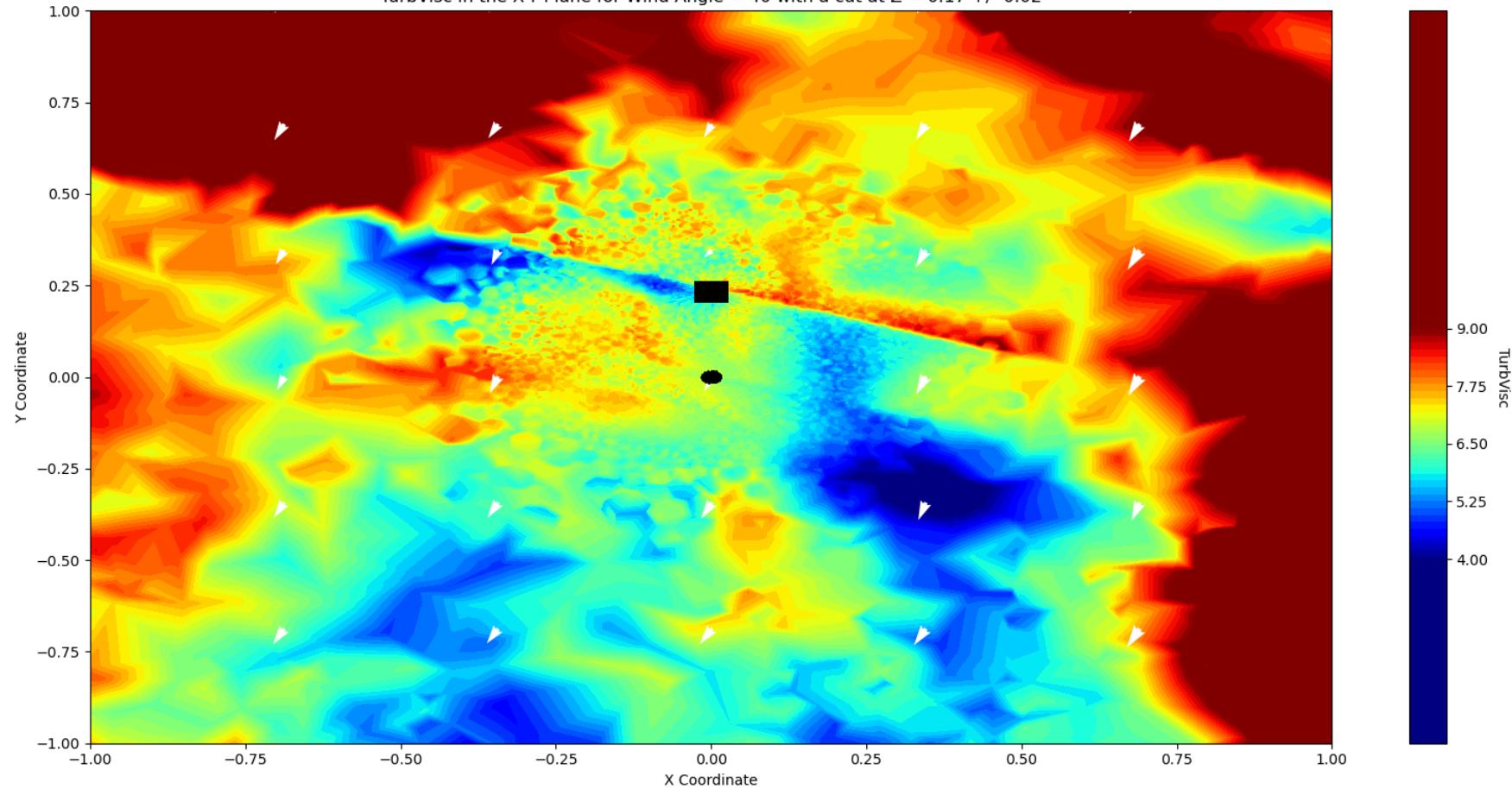
TurbVisc in the X-Y Plane for Wind Angle = 38 with a cut at Z = 0.17 +/- 0.02



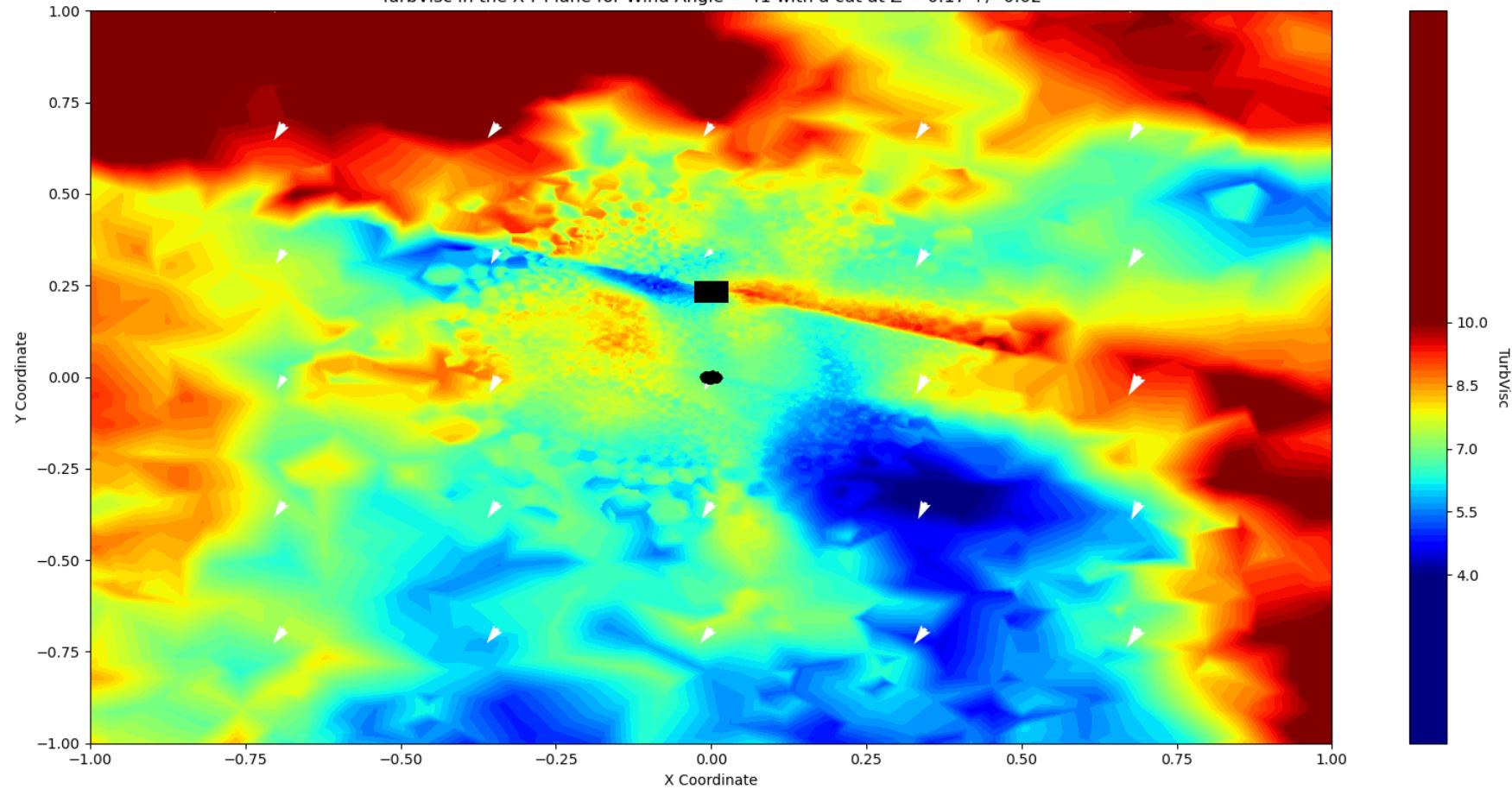
TurbVisc in the X-Y Plane for Wind Angle = 39 with a cut at Z = 0.17 +/- 0.02



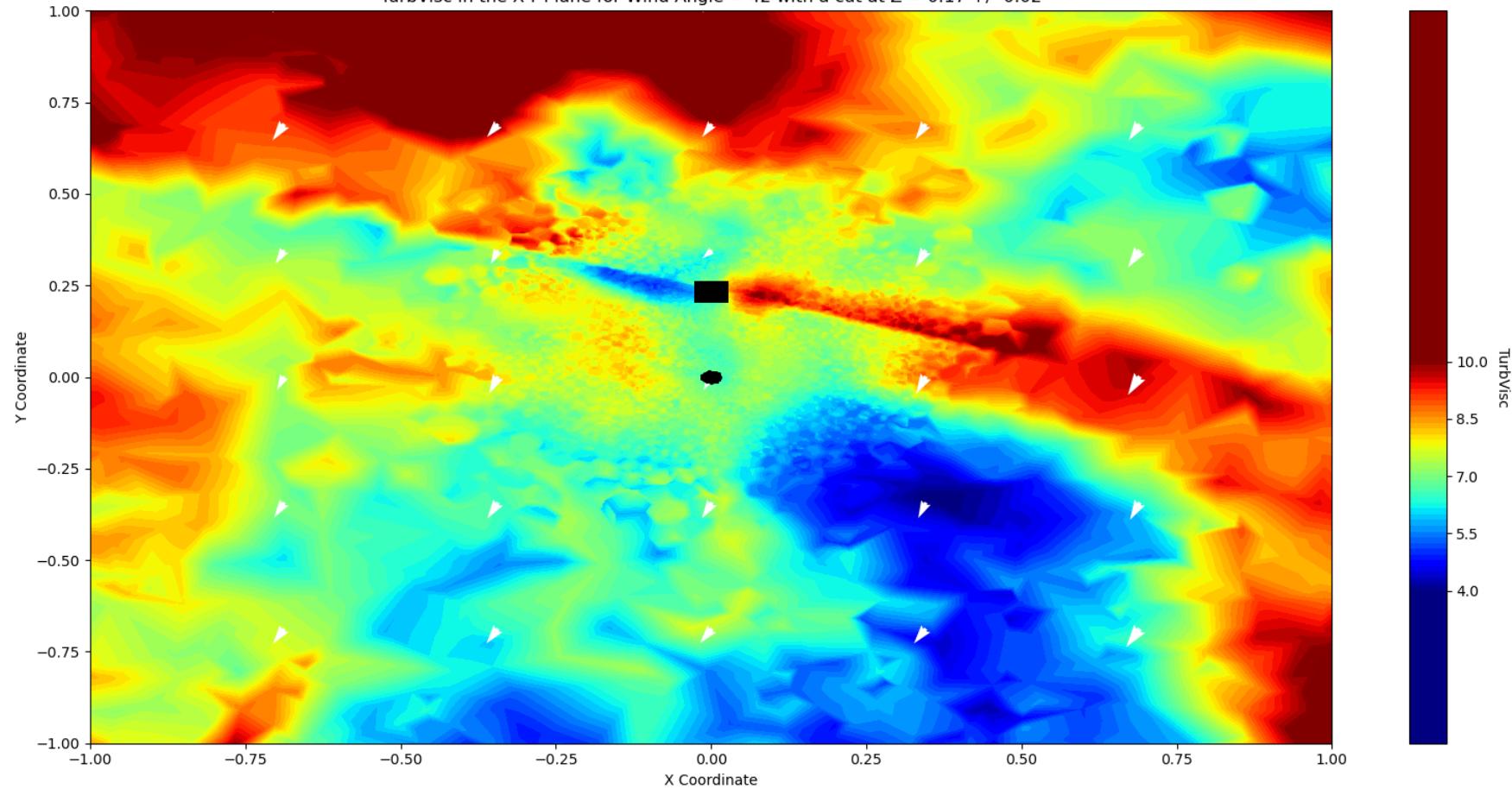
TurbVisc in the X-Y Plane for Wind Angle = 40 with a cut at Z = 0.17 +/- 0.02



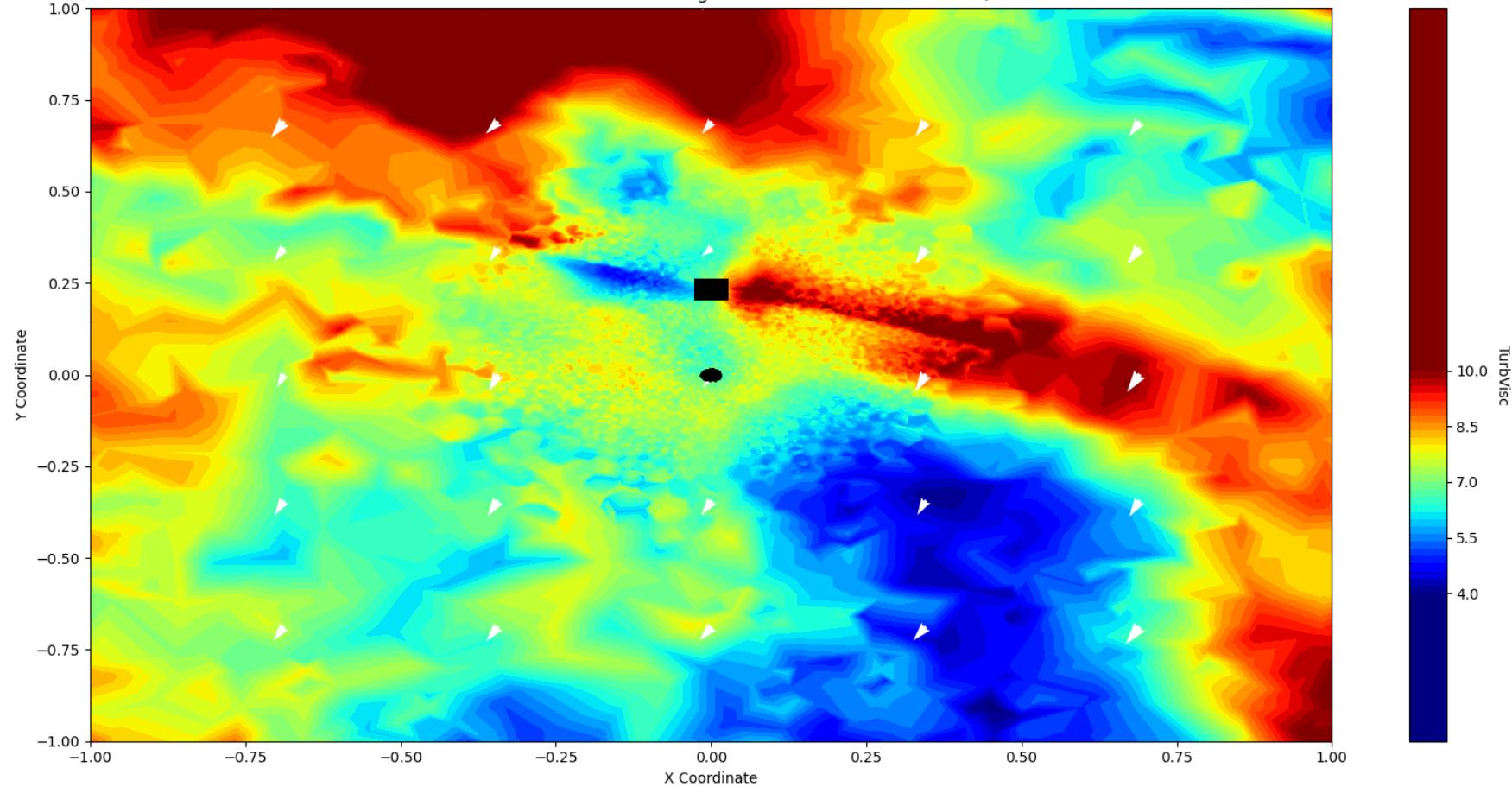
TurbVisc in the X-Y Plane for Wind Angle = 41 with a cut at Z = 0.17 +/- 0.02



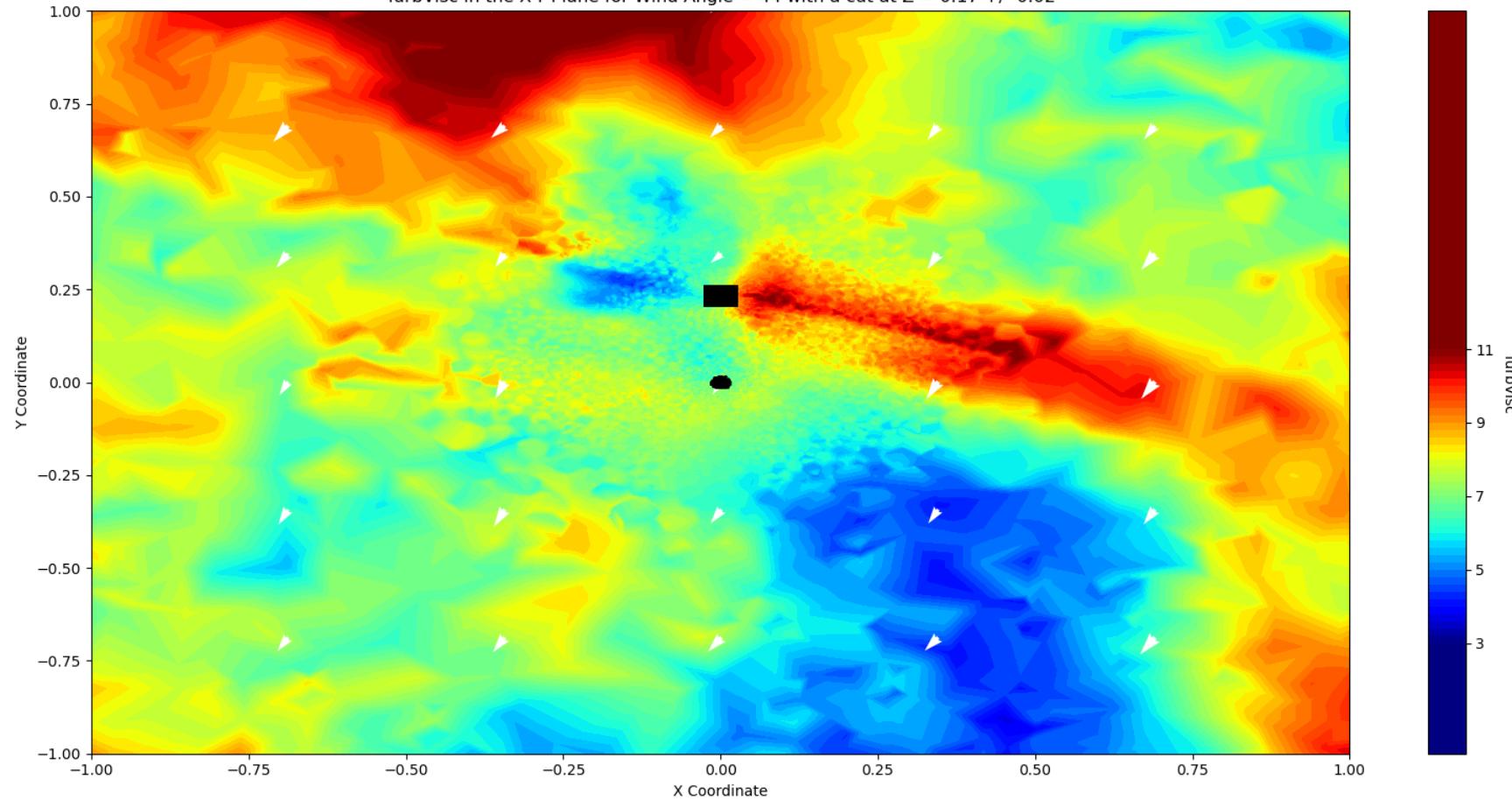
TurbVisc in the X-Y Plane for Wind Angle = 42 with a cut at Z = 0.17 +/- 0.02



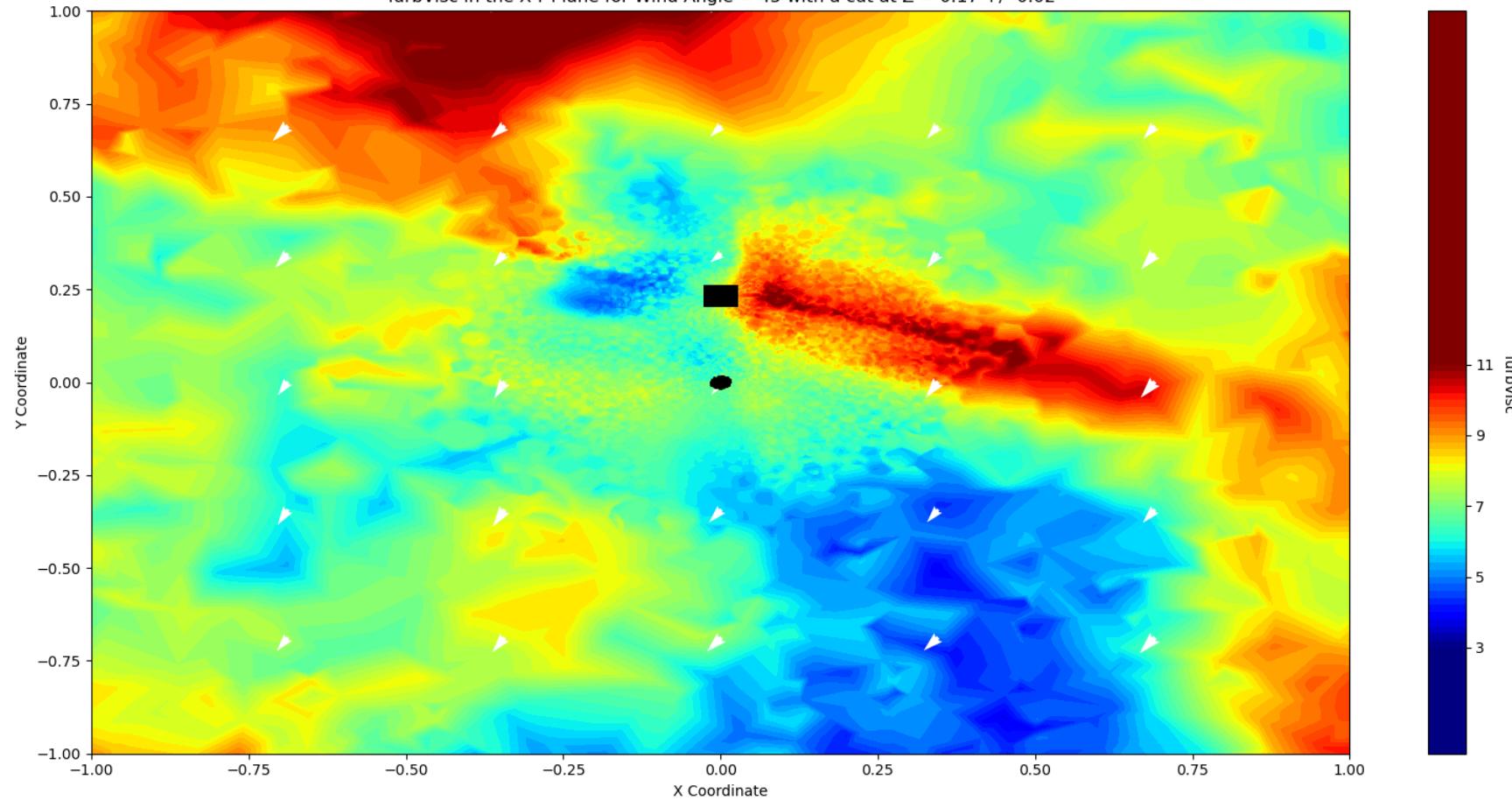
TurbVisc in the X-Y Plane for Wind Angle = 43 with a cut at Z = 0.17 +/- 0.02



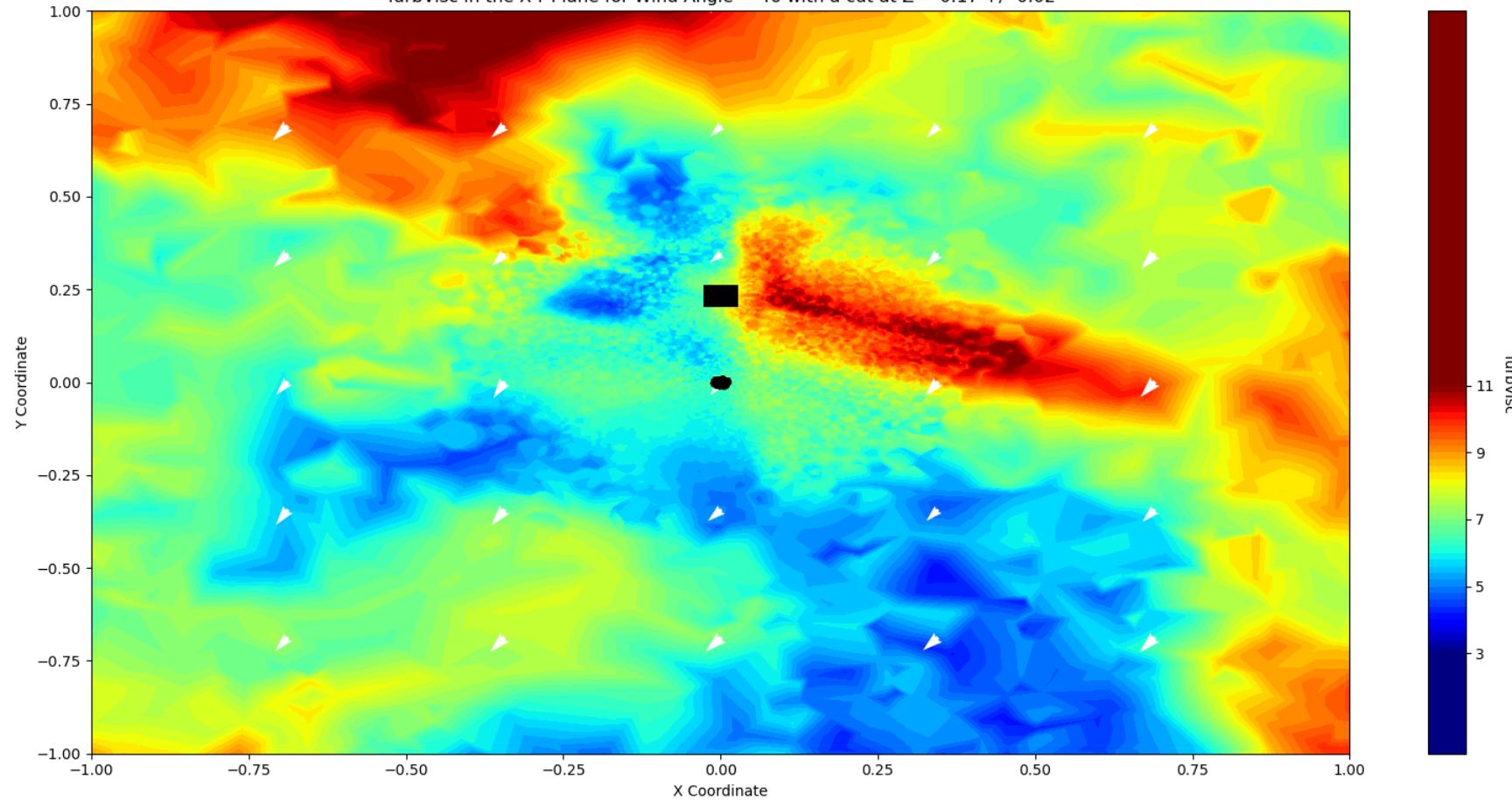
TurbVisc in the X-Y Plane for Wind Angle = 44 with a cut at Z = 0.17 +/- 0.02



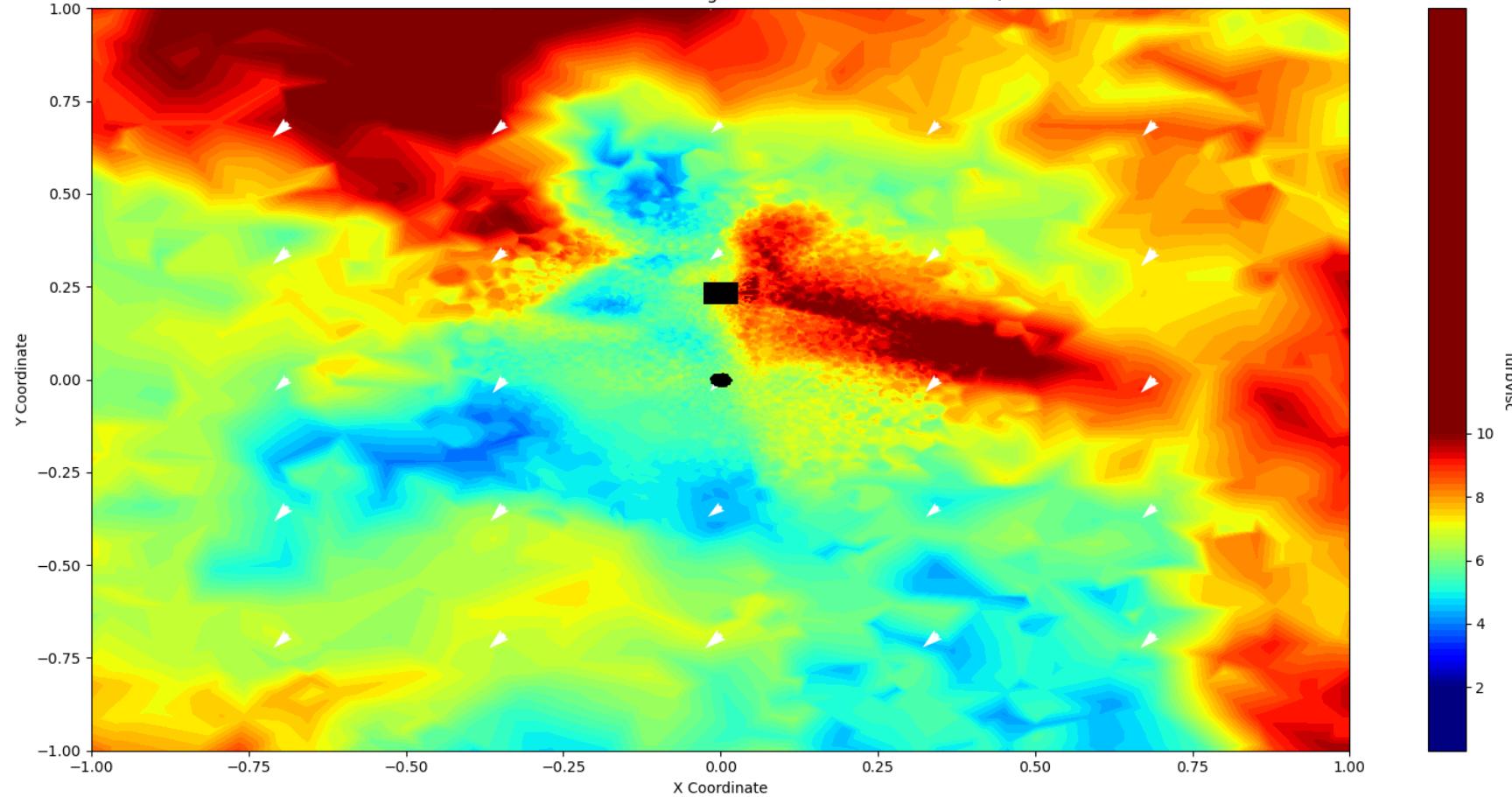
TurbVisc in the X-Y Plane for Wind Angle = 45 with a cut at Z = 0.17 +/- 0.02



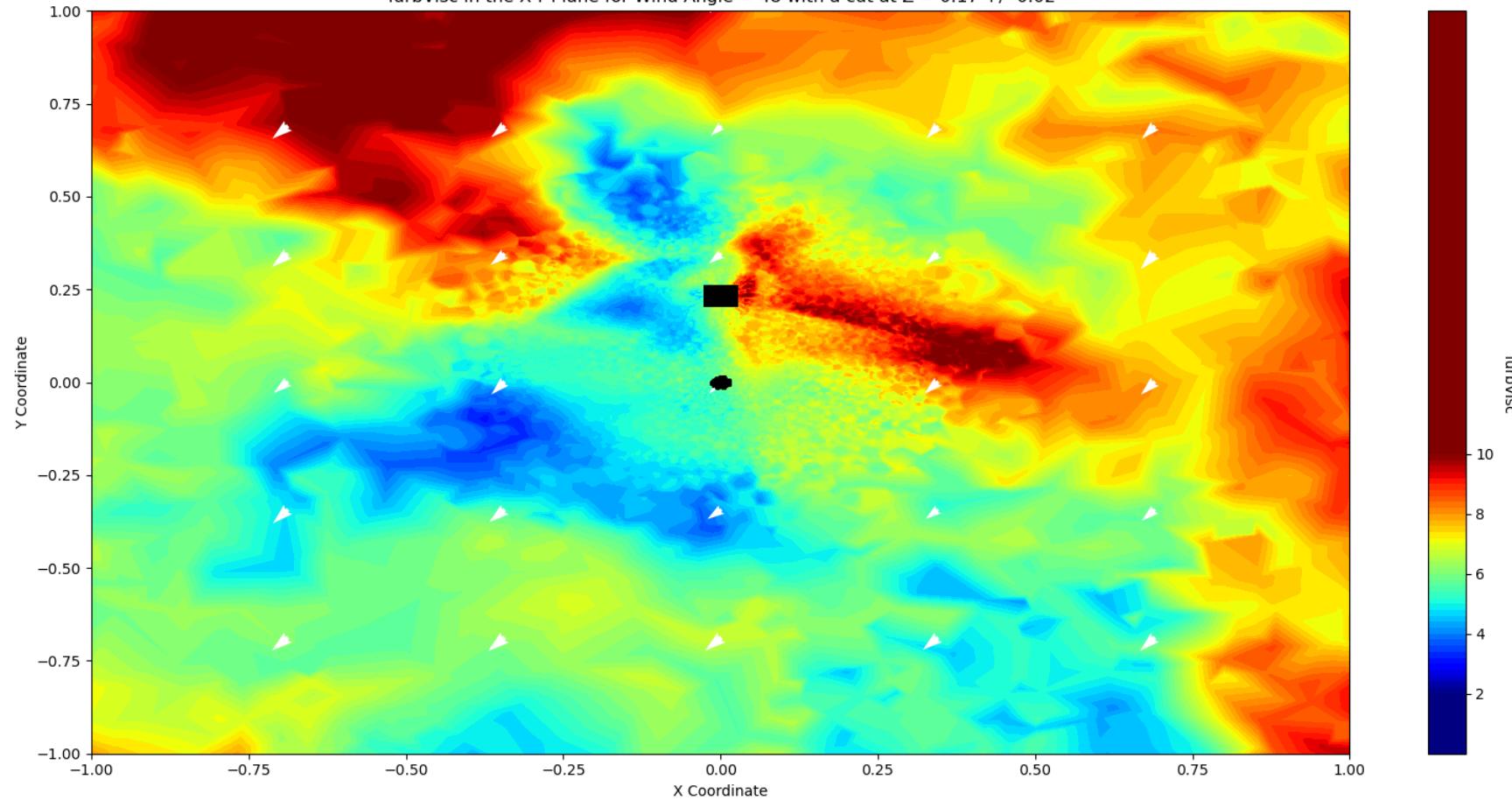
TurbVisc in the X-Y Plane for Wind Angle = 46 with a cut at Z = 0.17 +/- 0.02



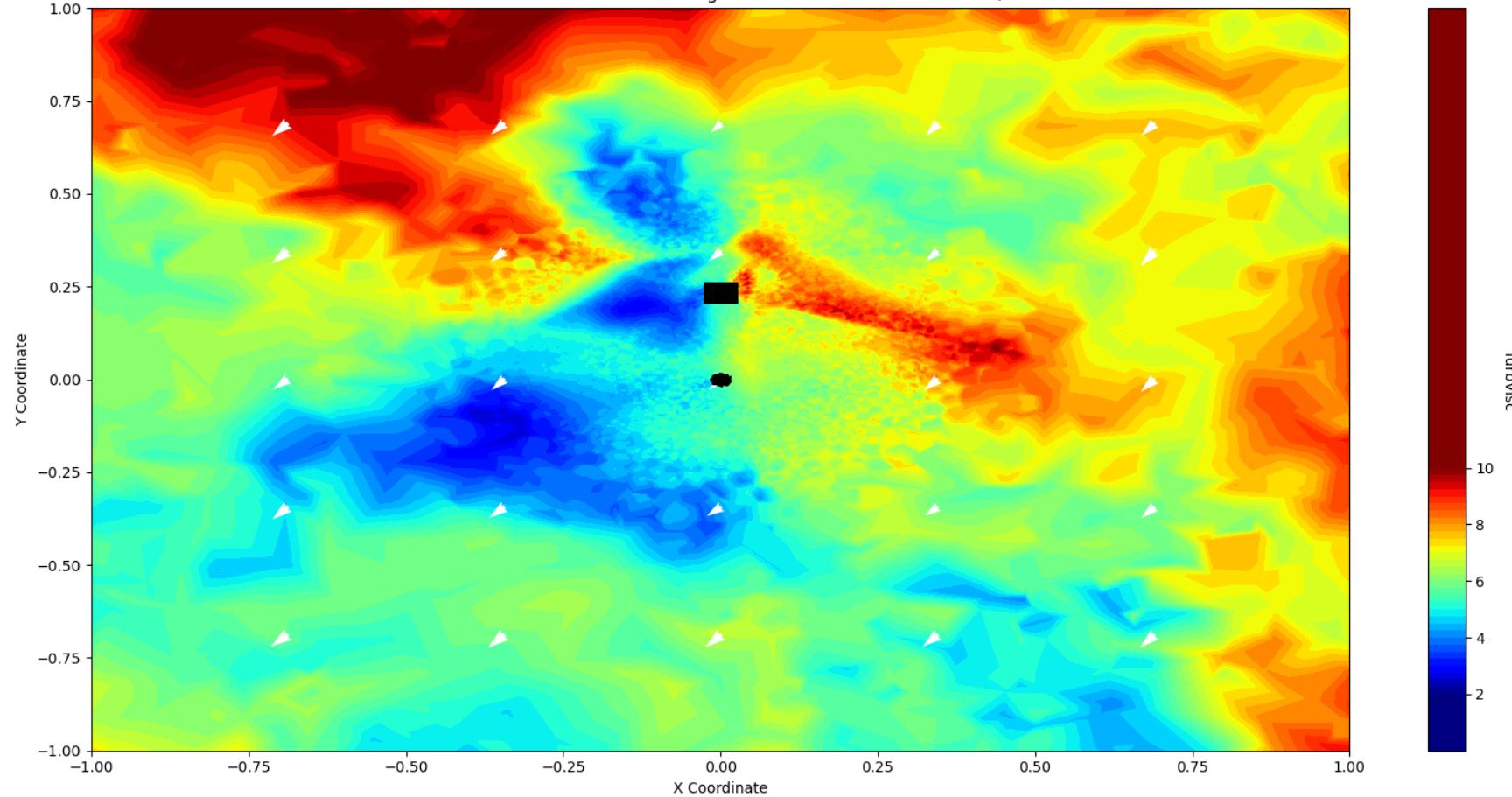
TurbVisc in the X-Y Plane for Wind Angle = 47 with a cut at Z = 0.17 +/- 0.02



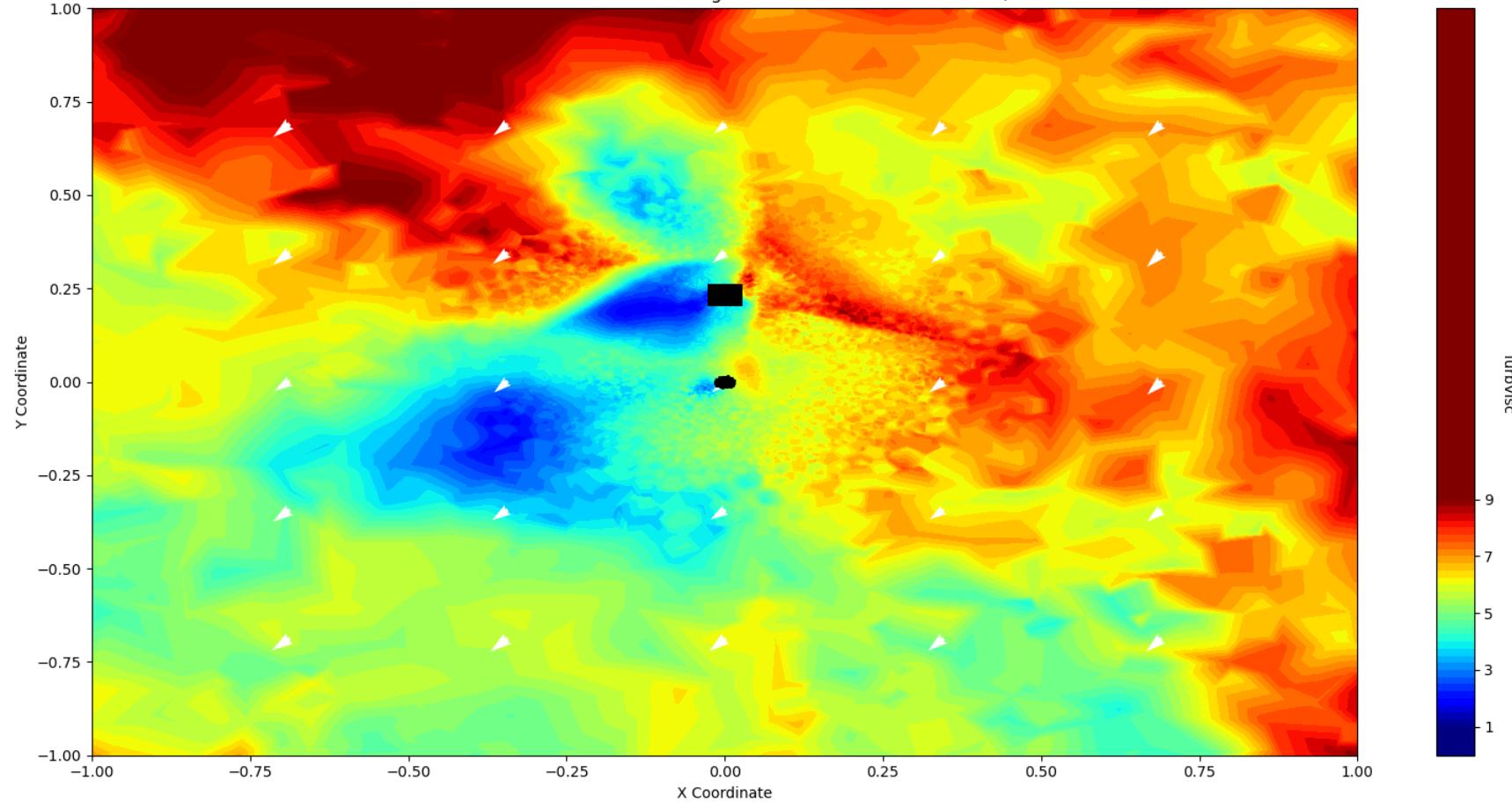
TurbVisc in the X-Y Plane for Wind Angle = 48 with a cut at Z = 0.17 +/- 0.02



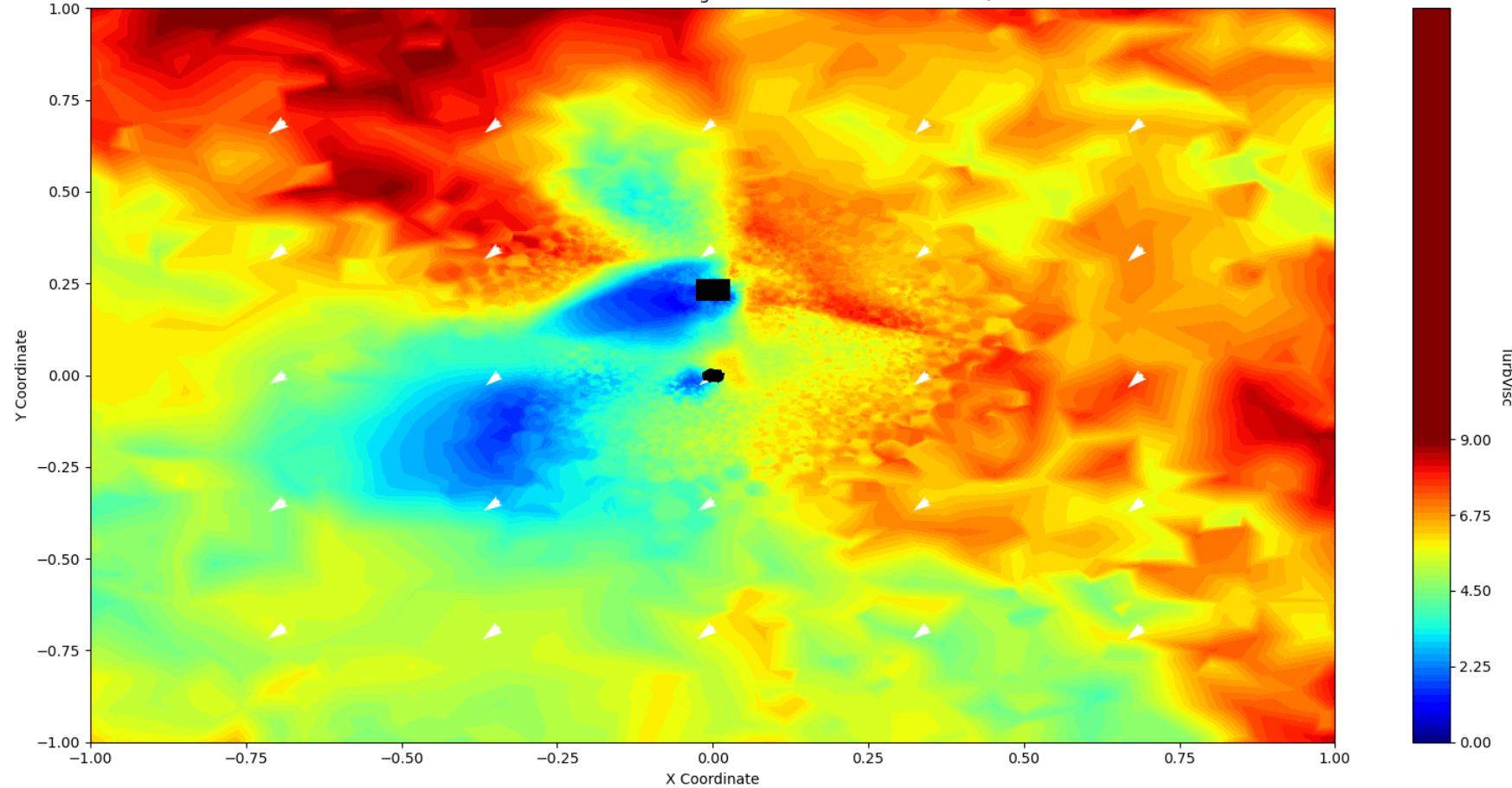
TurbVisc in the X-Y Plane for Wind Angle = 49 with a cut at Z = 0.17 +/- 0.02



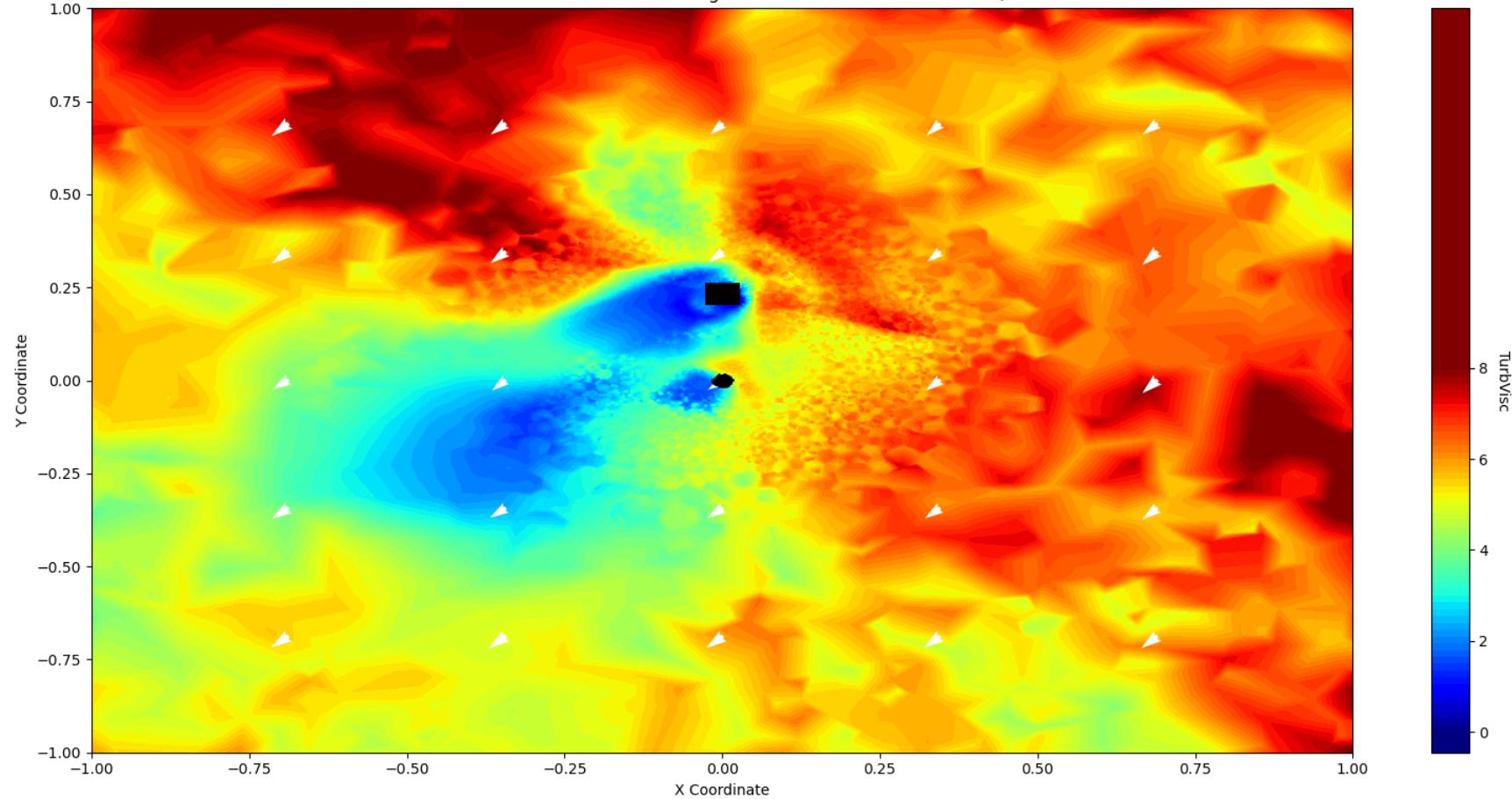
TurbVisc in the X-Y Plane for Wind Angle = 50 with a cut at Z = 0.17 +/- 0.02



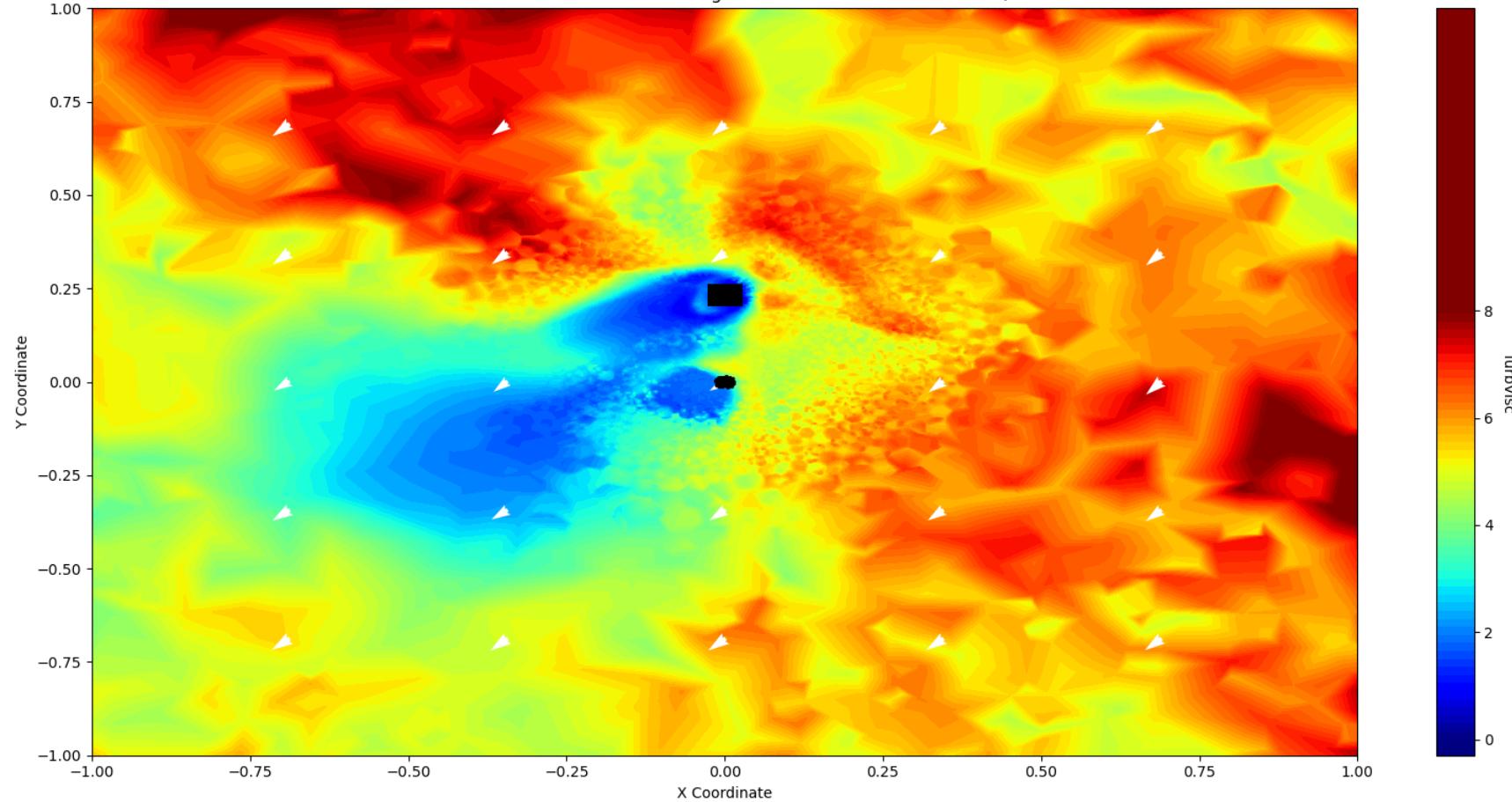
TurbVisc in the X-Y Plane for Wind Angle = 51 with a cut at Z = 0.17 +/- 0.02



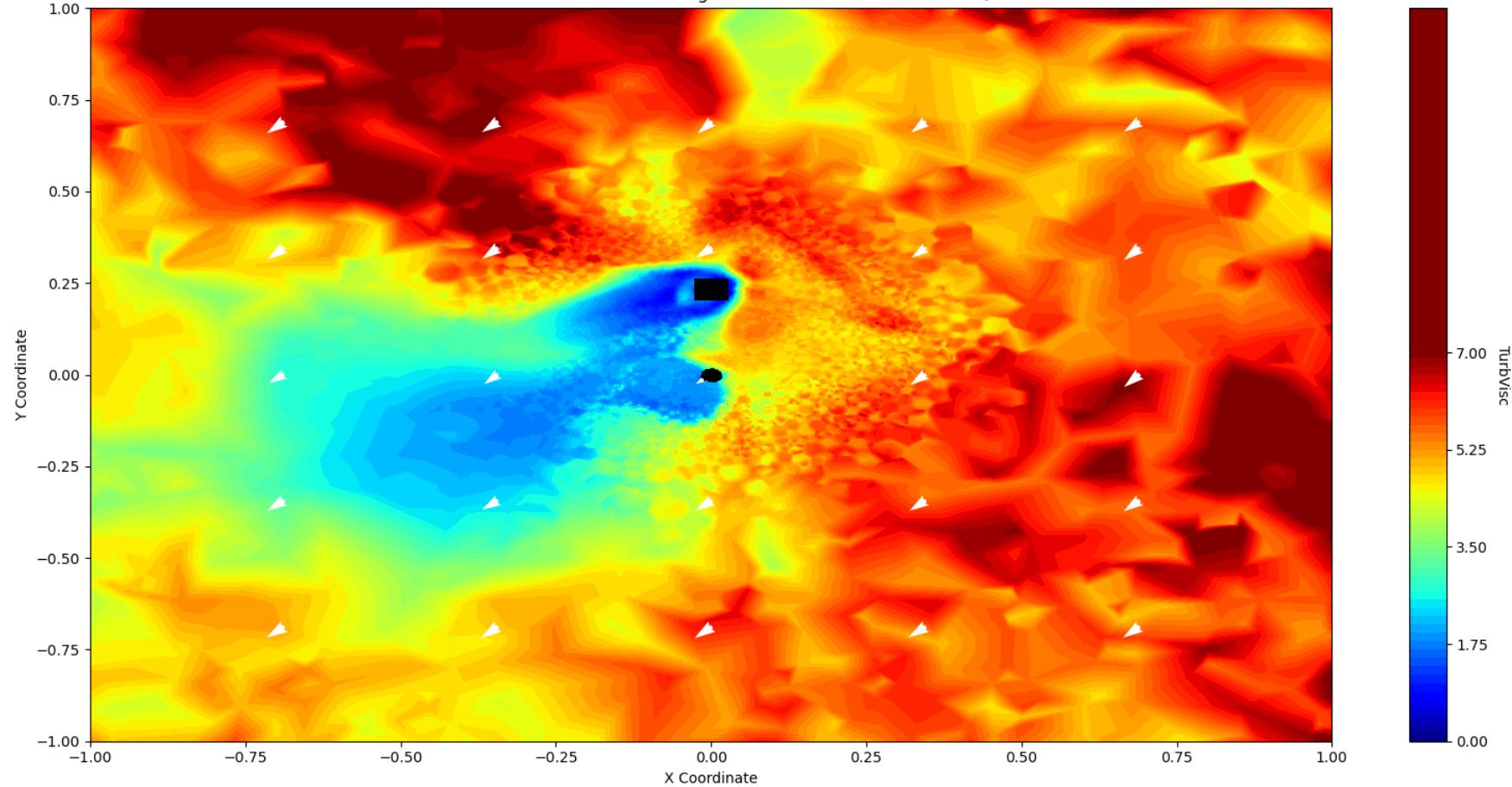
TurbVisc in the X-Y Plane for Wind Angle = 52 with a cut at Z = 0.17 +/- 0.02



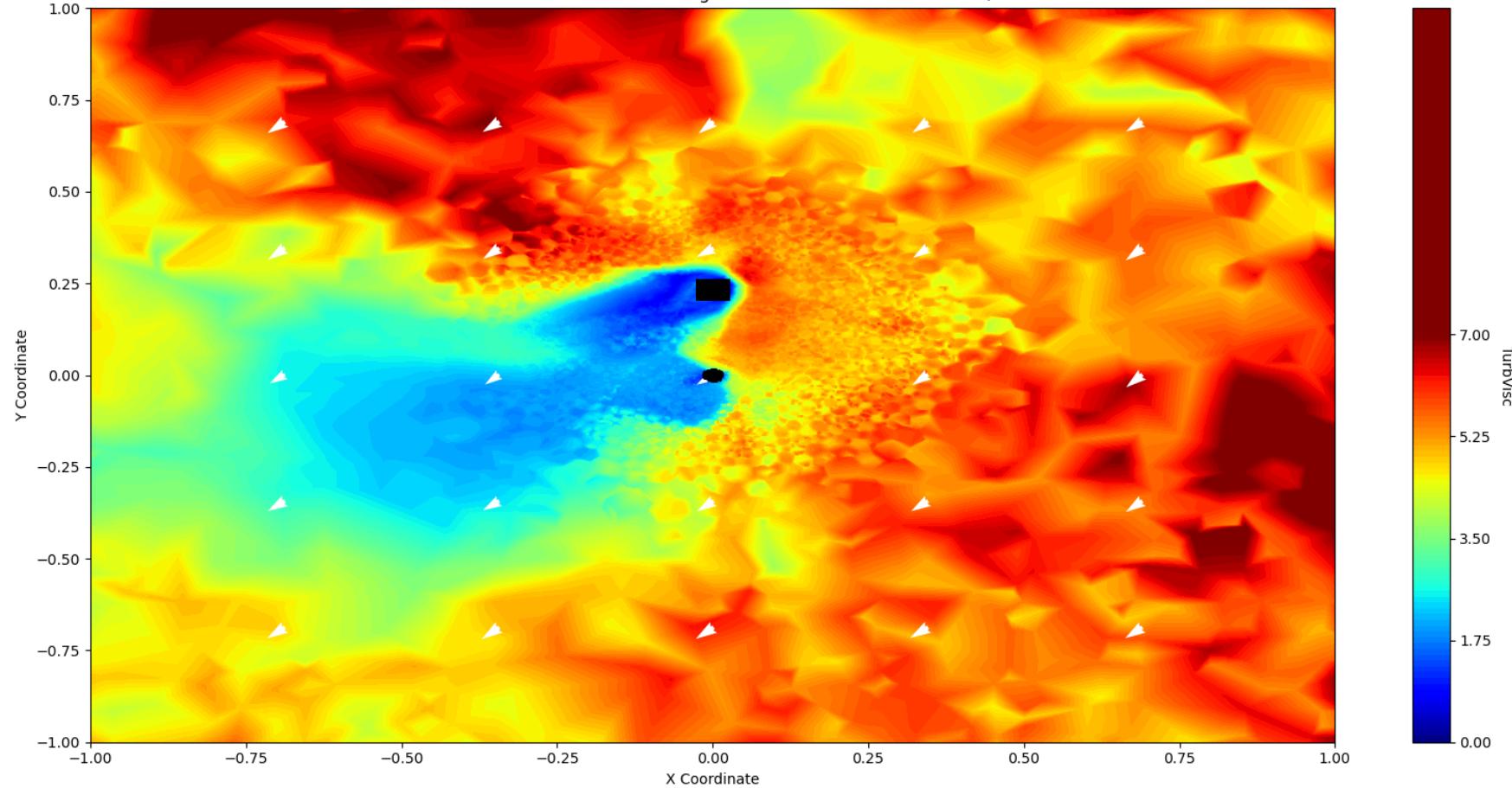
TurbVisc in the X-Y Plane for Wind Angle = 53 with a cut at Z = 0.17 +/- 0.02



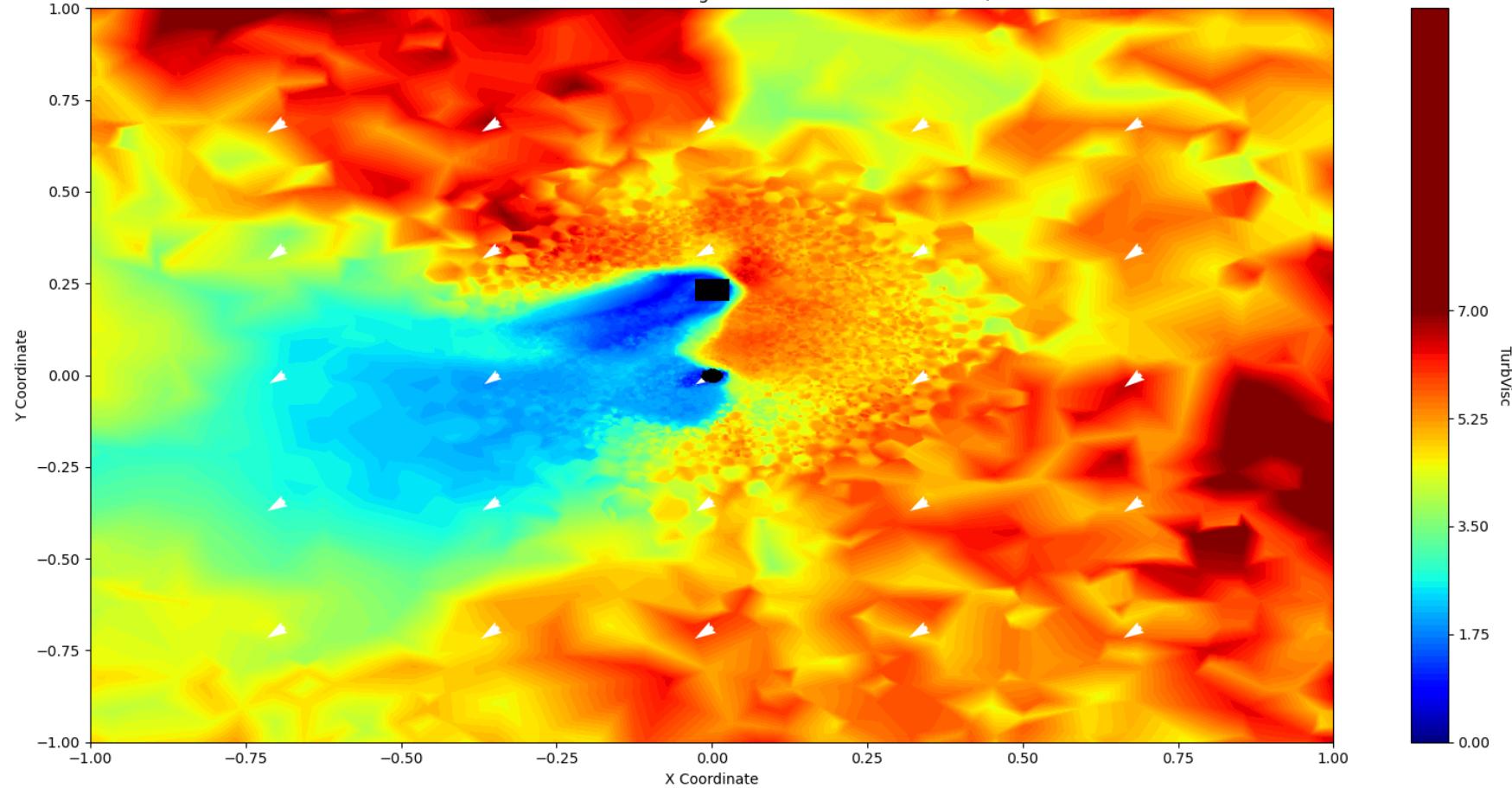
TurbVisc in the X-Y Plane for Wind Angle = 54 with a cut at Z = 0.17 +/- 0.02



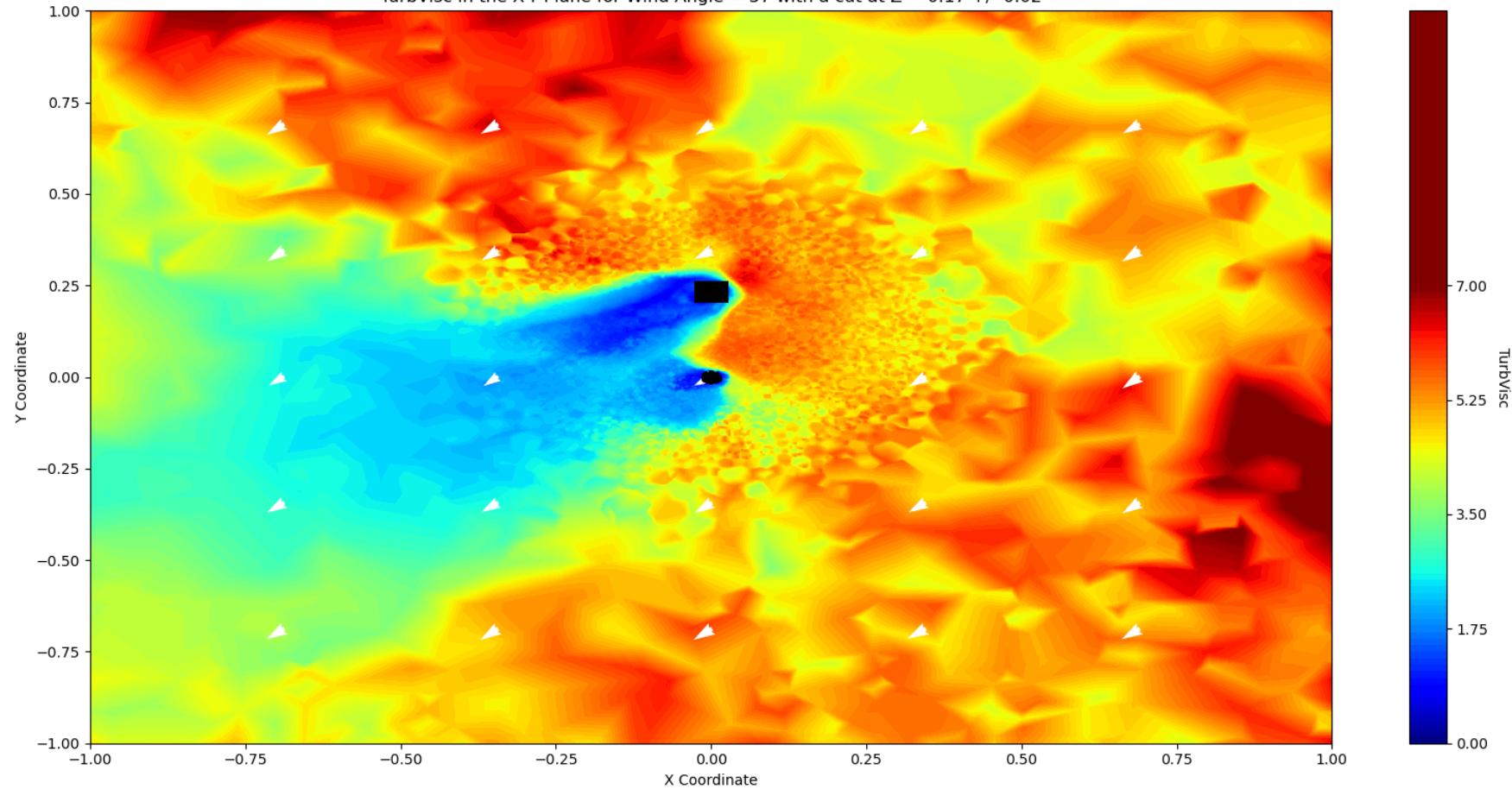
TurbVisc in the X-Y Plane for Wind Angle = 55 with a cut at Z = 0.17 +/- 0.02



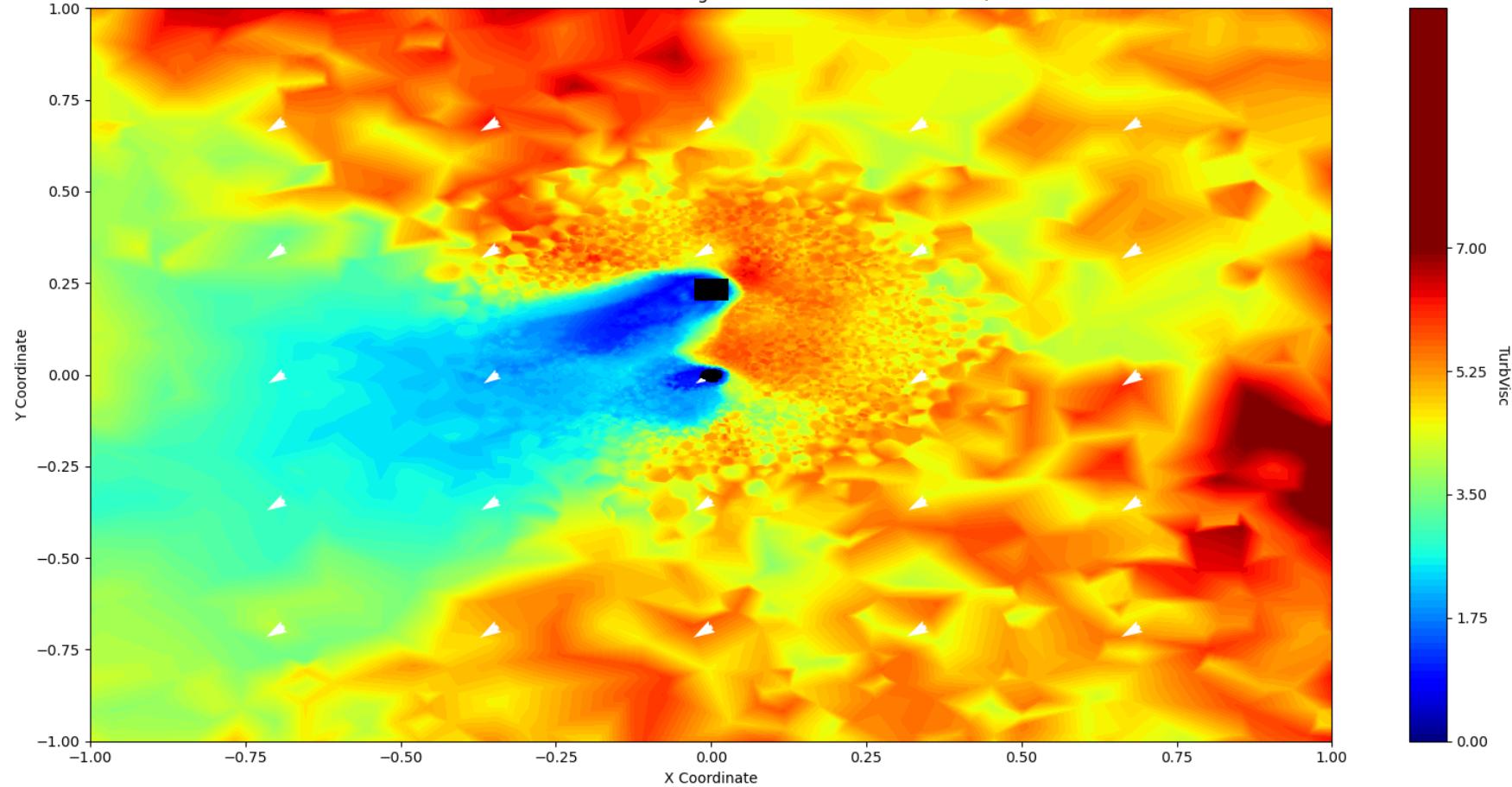
TurbVisc in the X-Y Plane for Wind Angle = 56 with a cut at Z = 0.17 +/- 0.02



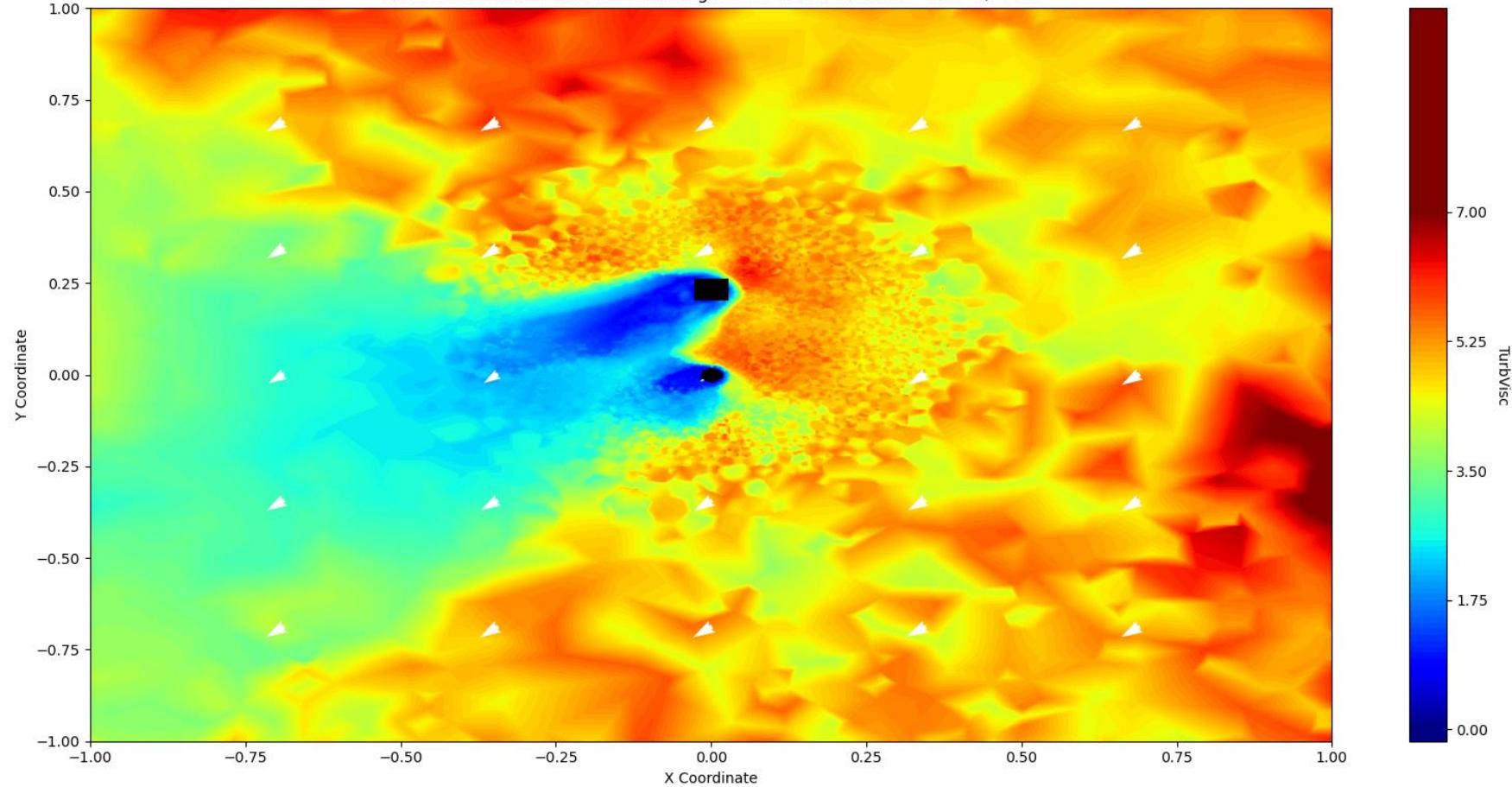
TurbVisc in the X-Y Plane for Wind Angle = 57 with a cut at Z = 0.17 +/- 0.02



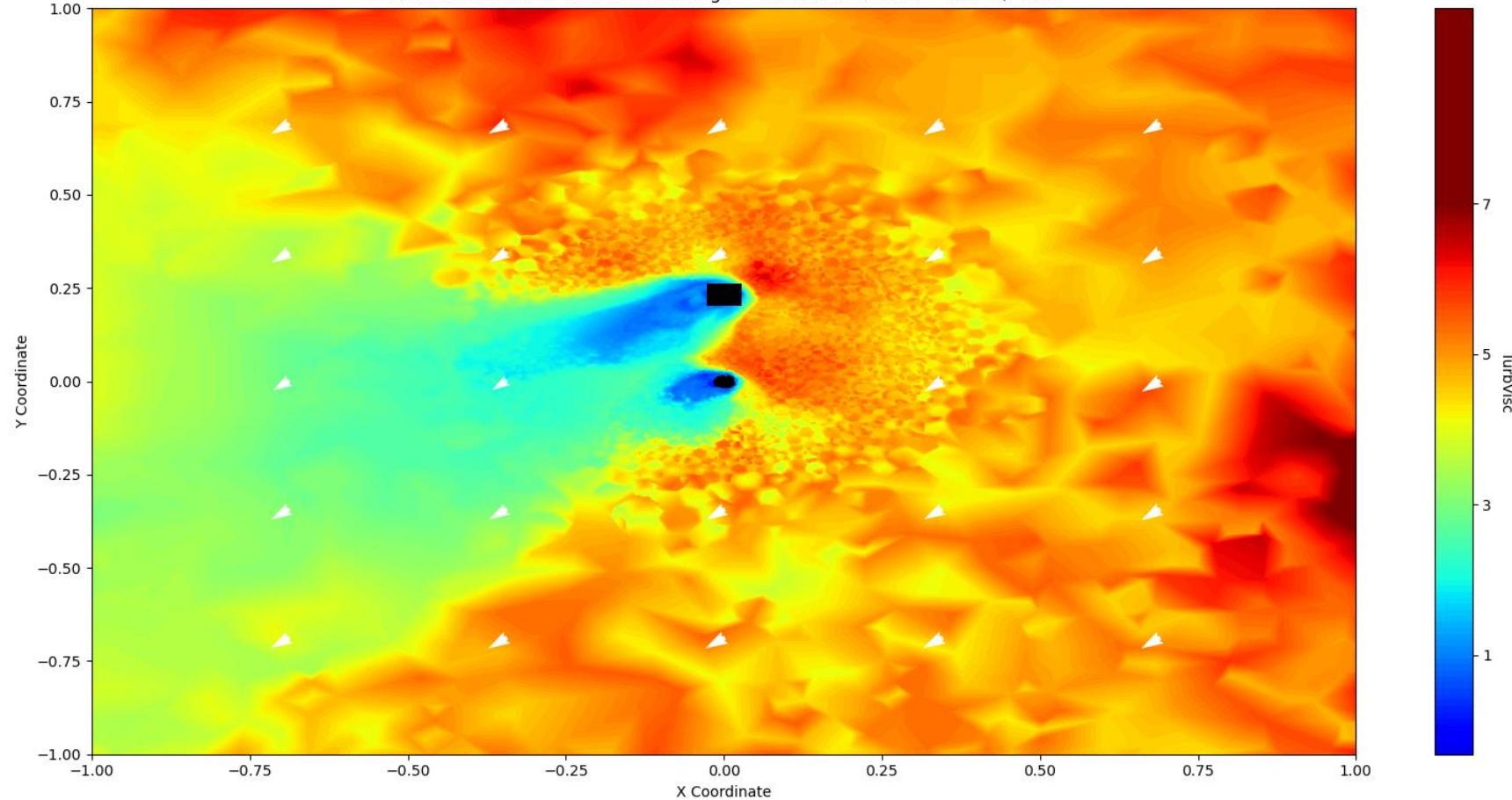
TurbVisc in the X-Y Plane for Wind Angle = 58 with a cut at Z = 0.17 +/- 0.02



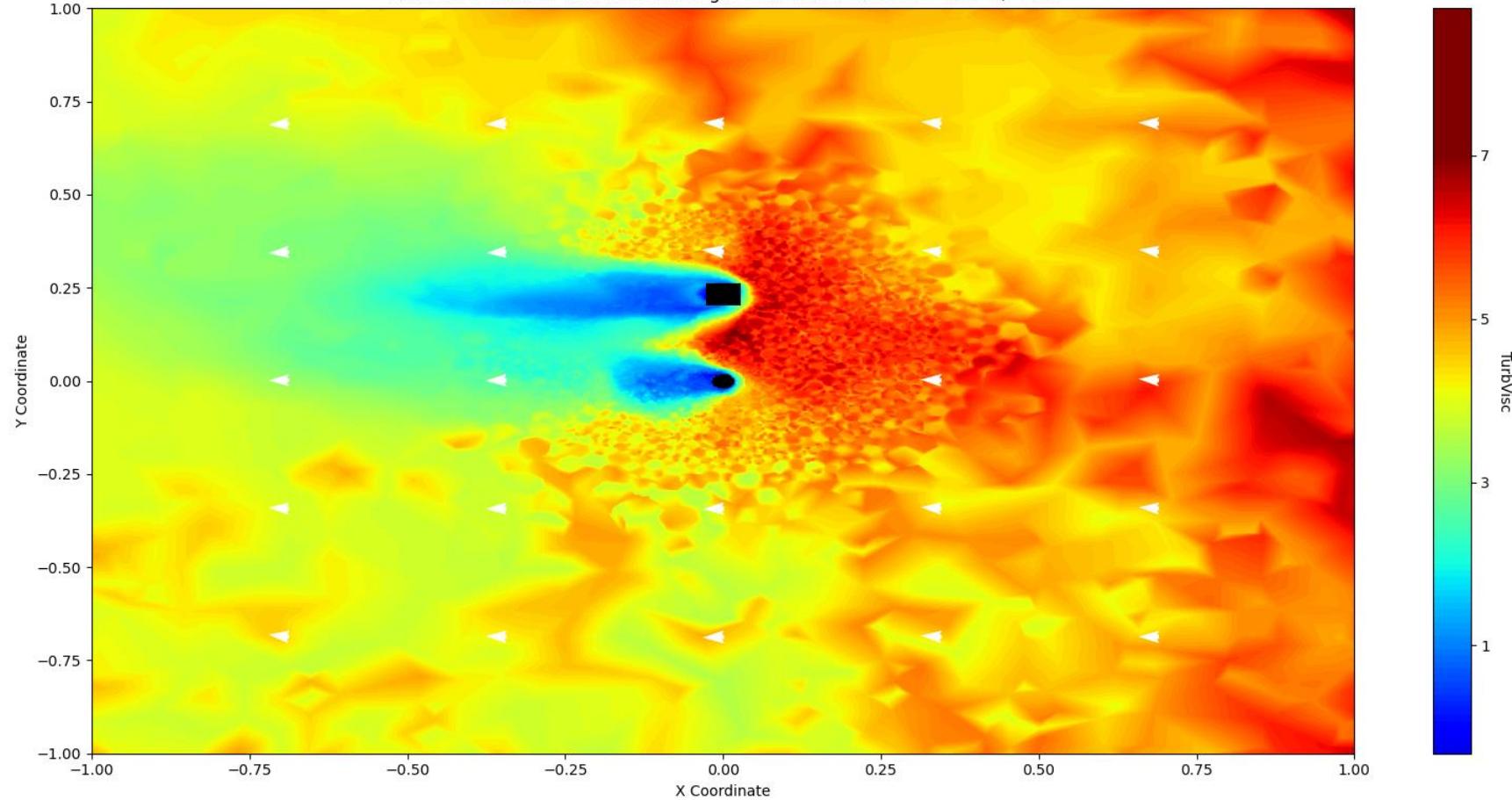
TurbVisc in the X-Y Plane for Wind Angle = 59 with a cut at Z = 0.17 +/- 0.02



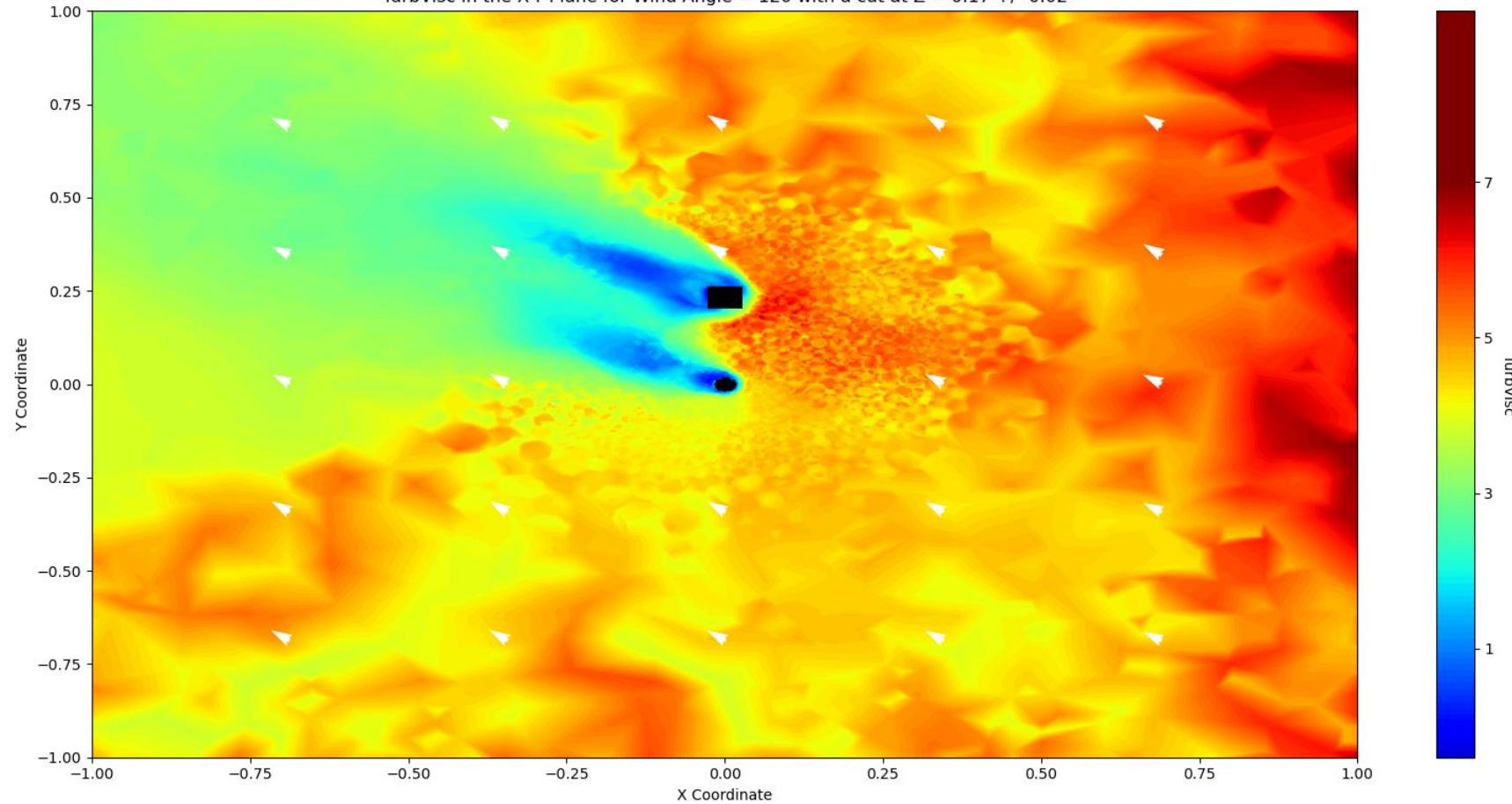
TurbVisc in the X-Y Plane for Wind Angle = 60 with a cut at Z = 0.17 +/- 0.02



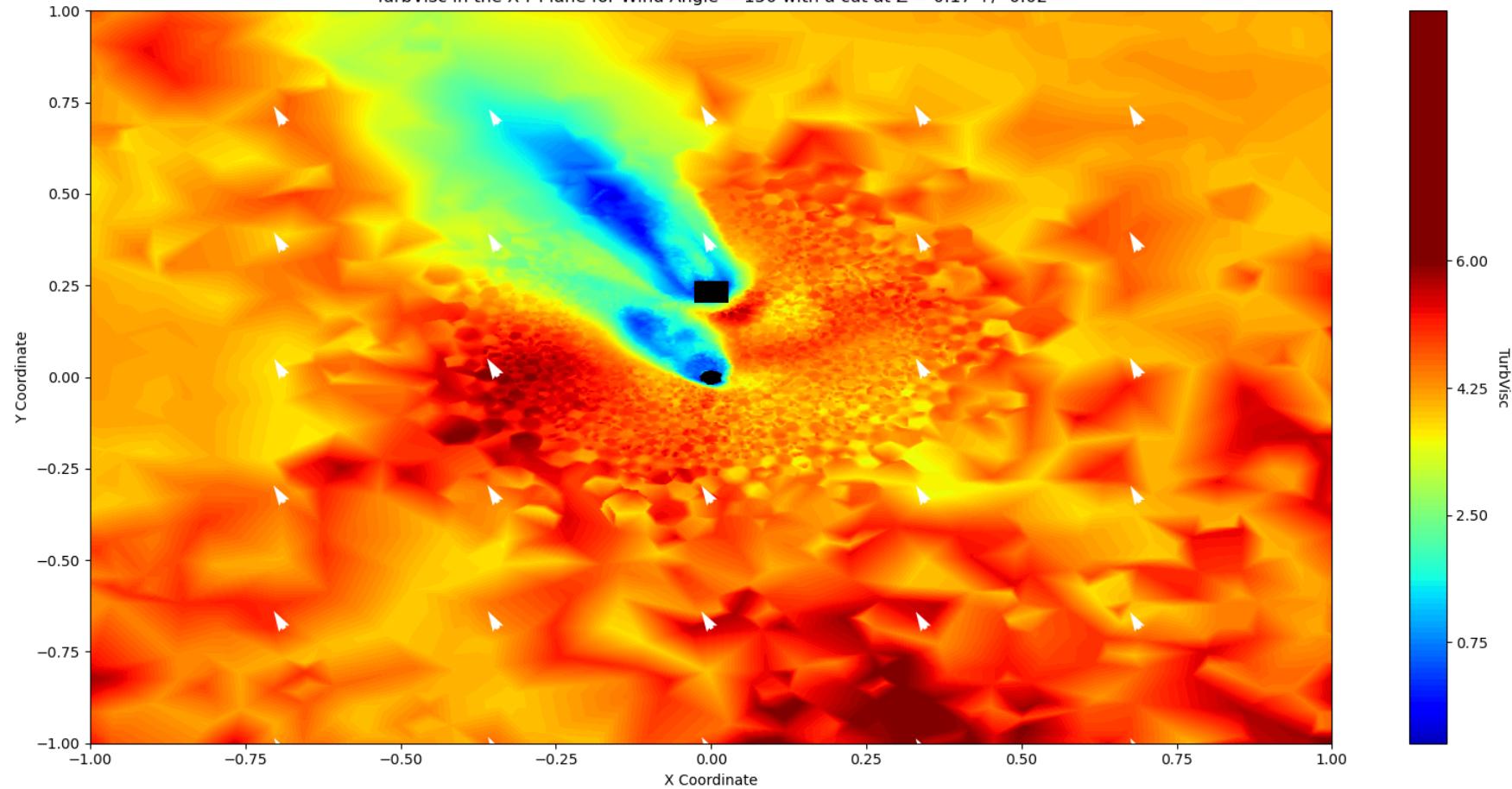
TurbVisc in the X-Y Plane for Wind Angle = 90 with a cut at Z = 0.17 +/- 0.02



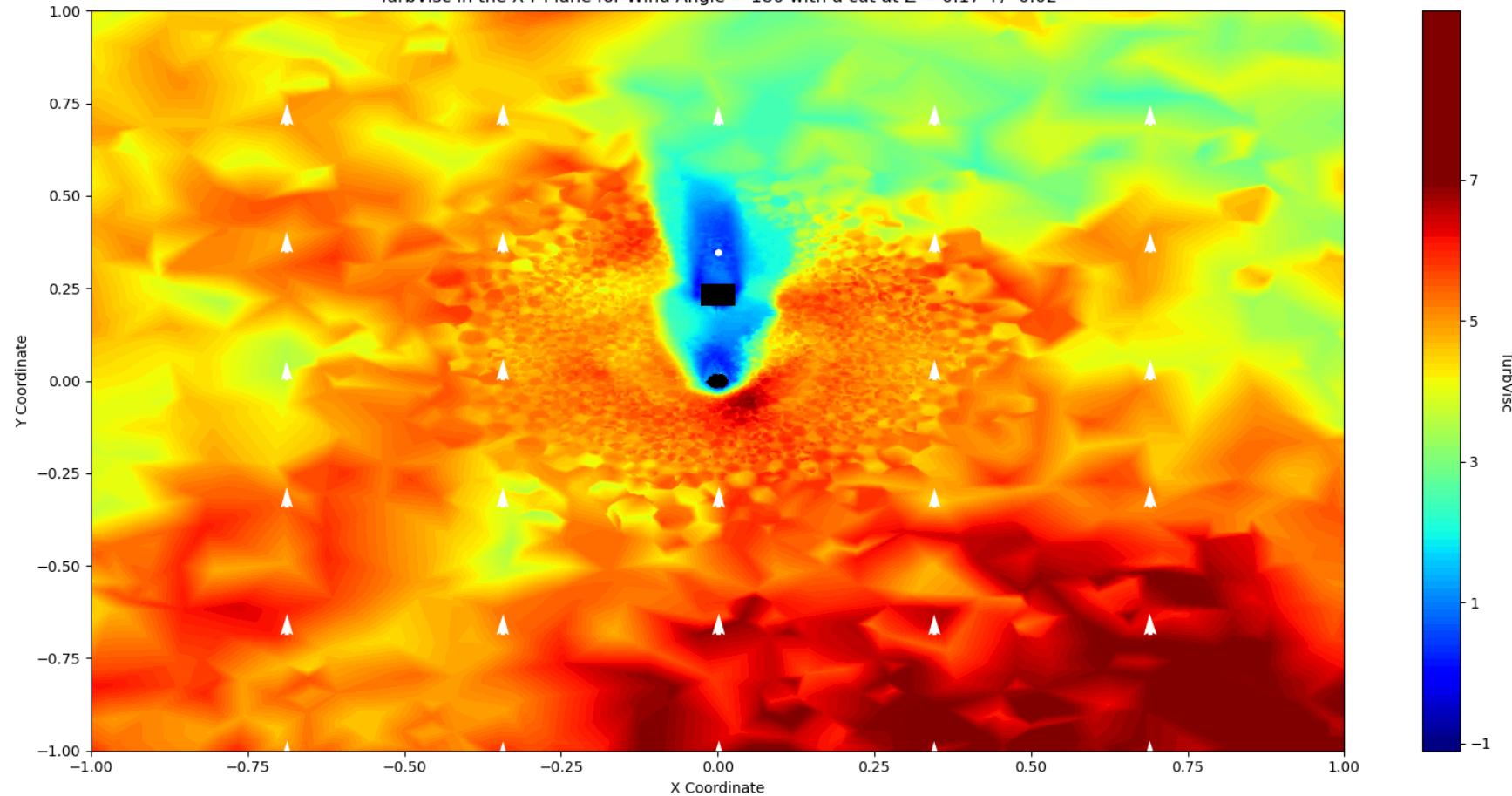
TurbVisc in the X-Y Plane for Wind Angle = 120 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 150 with a cut at Z = 0.17 +/- 0.02



TurbVisc in the X-Y Plane for Wind Angle = 180 with a cut at Z = 0.17 +/- 0.02



Statistical Comparisons

Statistical Comparisons - MSE

Type	Data – Std Normal (NC - 27450)	Data + Cont (NC - 4660)	Data + Cont + Boundary (NC - 2595)
Pressure	0.439028	0.264865	2.34936
Velocity:0	0.7123	0.050552	0.144433
Velocity:1	0.758113	0.16956	0.249833
Velocity:2	0.9216	0.004823	0.011697
TurbVisc	0.998532	0.195052	2.276149

Statistical Comparisons – R2

Type	Data – Std Normal (NC - 27450)	Data + Cont (NC - 4660)	Data + Cont + Boundary (NC - 2595)
Pressure	0.480088	0.843309	-0.38986
Velocity:0	0.726983	0.950401	0.858292
Velocity:1	0.792097	0.835225	0.757216
Velocity:2	0.918326	0.852572	0.642446
TurbVisc	0.998113	0.998579	0.983414

Some Next Steps

Modify boundary loss (perhaps weak no slip condition)

Convert scripts for TPU use

Code Saturne Data for new angles – [15, 45, 75, 105, 165] (for Xiasu)